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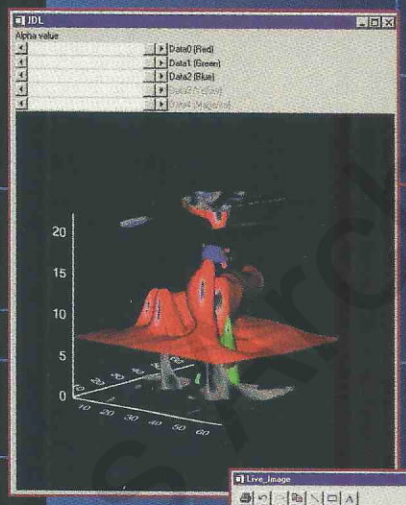

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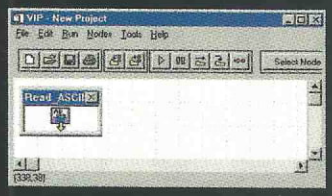

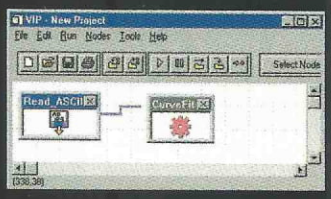

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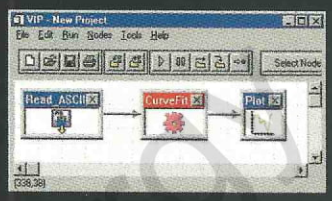

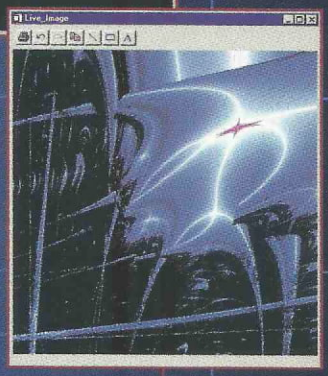

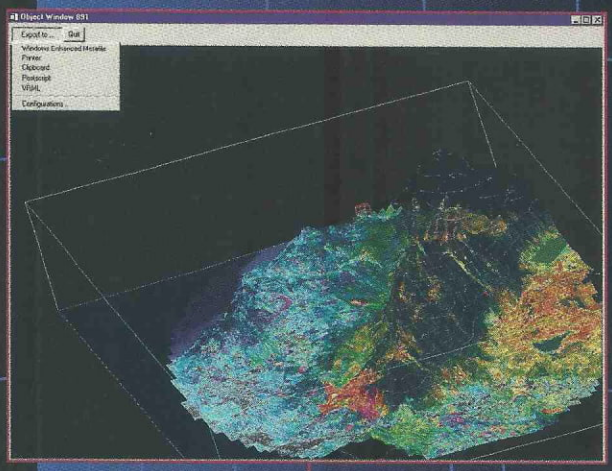

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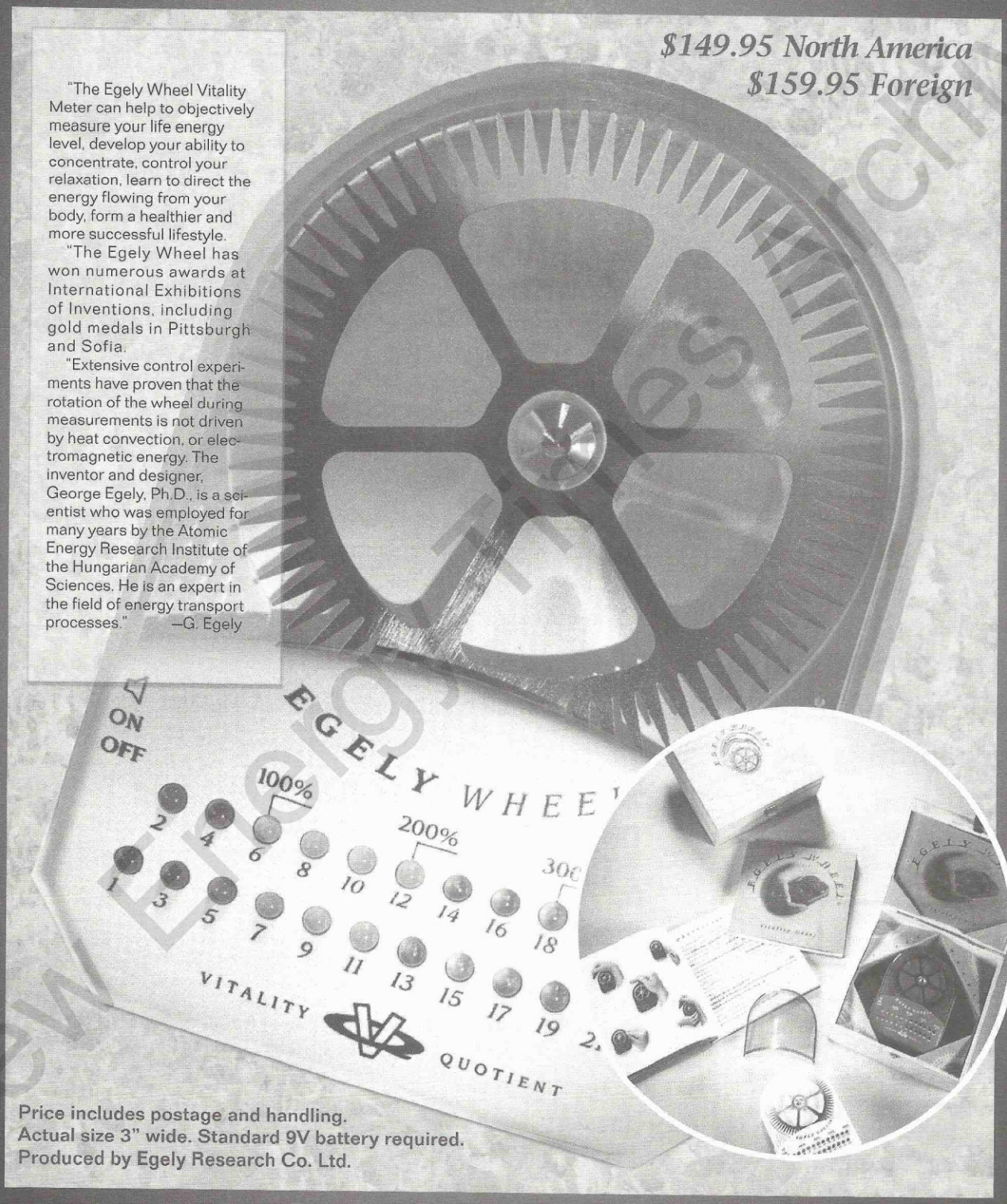

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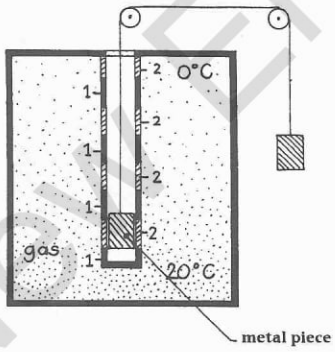
The Magazine of New Energy Technology

Can Maxwell's Demon Be Captured?

pp. 12-39

One of many proposed methods for capturing the Demon. . .



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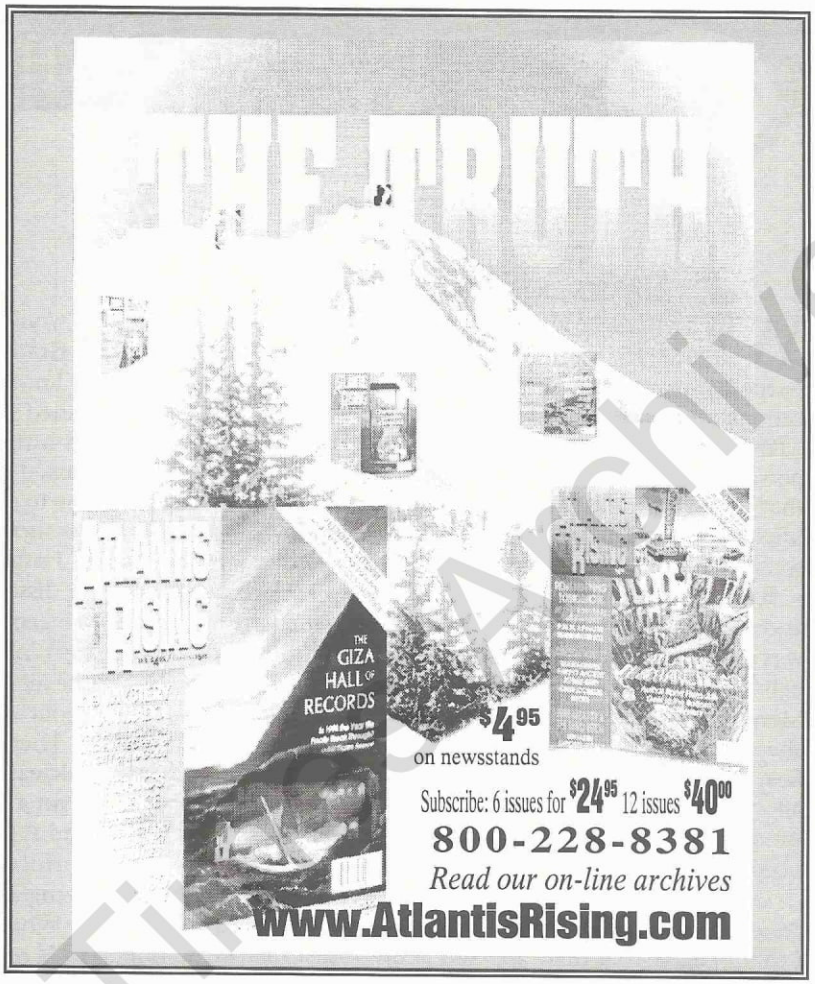

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LETTERS TO THE EDITOR

The New Scientific Consciousness

Why were early twentieth century physicists so keen to abolish the aether? Remember that around that time, telepathy, psycho-kinesis (levitation), and spiritual communications were entering westerners' consciousness. If such things were true, that would mean that man was a being of enormous power. Not something easy to live with. "Our deepest fear is that we are powerful beyond measure," said Nelson Mandela. Might it not seem that our actions here on Earth would be somewhat ridiculous in the light of such power?

It was thus important to bring humanity back to its senses and to diminish our "delusions" of grandeur that the aether was abolished, that vacuum was Nothing and that those who believed in ESP were simply crazy. Much more comfortable! More recently, however, some discomfort has returned in the shape of parapsychological studies showing "beyond reasonable doubt" that physics effects are real. More scientific circles are coming to the conclusion that this evidence cannot be dismissed, and that therefore a supporting physical theory is needed to explain it.

Dr. Mallove's editorial comment (*IE* #38) that there are "many competing dissident theories" post-SR is pertinent. But I cannot agree that there are "too many"—just that we do not at present have a strategy of coping with such a wealth of newly-created ideas. This is something that the Internet especially will force us to confront, and which has been a long time in coming. For instance, the British and American political systems are incapable of dealing with more than two political spheres of thought, despite the pluralism of many years!

Behind all this behavior, in my view, is our desperate search for self-identity and self-esteem, the need to be on the "winning side." The reality that I use—to think of myself as an "observer," separate even from my own physical body—is that there are no sides, and no way of losing. My identity is Me, I need nothing else: a position of ultimate strength. Stephen Hawking's comment that "the theory of relativity is now completely accepted by the scientific community" could therefore be interpreted as meaning, "I feel confident because I believe there are a mass of others out there willing to say the same thing," which would actually be a position of self-doubt.

The "many dissident theories" all probably contain both truths and untruths, and therefore they and their authors all deserve respect. No one need take criticism of their ideas personally and it is necessary for everyone to extend the hand of friendship to all others. By these means a strong and flexible community will establish itself as being the obvious place to belong—in fact the only place that there is. I hope that *IE* can be one of these places and assist in creating the new scientific consciousness.

Stephen Lawrence
Cambridge, England

Arc Explosion

I would like to contribute further to the material on Graneau's arc explosion (Graneau *et al.*, *IE* #41).

I noted in the extracted letter that I sent to Graneau (published with their article in *IE*) that in 1994 I had published an article with Sundaresan in which we show that an arc passed through water in the presence of oxygen had given rise to nuclear reactions, producing iron (a follow-up by others showed that nickel and cobalt were also produced).

I suggest that the passage of the arc produces enough heat to dissociate substantial amounts of water to hydrogen and oxygen. I have two lines of reasoning for this. First of all, at the heart of an arc, where it actually originates from the electrodes, the temperature is about 4000°K. At 4000° and 1 Atm pressure, about 50% of the water is converted to hydrogen and oxygen.

There is another reason for my further suggesting the nuclear activities behind Graneau's phenomena. This comes from an obscure paper which I happen to have, by G. Speri and P. Zorzi (*Foundations of Mathematics and Physics*, eds. U. Bartocci and J.P. Wesley, Benjamin Wesley Publishers, Perugia, Italy, 1989, p. 237).

What these authors say is that they made experiments in 1974 in passing arcs through petroleum vapor. They give calculations which show that under these circumstances there will be sufficient deuterium present from natural causes to allow for the possibility of the deuterium-deuterium fusion reaction and show that the amount of energy then produced would be enough to explain the extra energy which they noted from their measurements on passing an arc.

I suggest that this gives support for the idea that the natural deuterium present in water, when obtained out of the water by thermal dissociation, gives rise to enough deuterium to cause heat energy as the basis to the explosion.

It is interesting to note that this work carried out in 1974—substantially before the Pons-Fleischmann work—gave rise to the idea of a D-D nuclear reaction.

John O'M. Bockris
Distinguished Professor
Texas A&M University (1982-1997)

Scientific "Truths"?

A hearty and heartfelt thank you and congratulations on reporting the successful aether (*IE* #39) and cold fusion experiments (*IE* #40). Wow! It looks like we're there, and soon much of the denials and obfuscation that have stifled progress will be evaporating.

I would like to add a comment about something that you may have overlooked in one of your articles. In Issue 39 (p. 9), Dr. Mallove ends his "Breaking Through" editorial with a short list of conclusions of which he is personally certain. They include things like the existence of energetic

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aether with biophysical properties, the need to revise the Second Law of Thermodynamics, and more. Amen! To this list I would humbly propose two others:

1. *The very delicate and restrained use of the principle of "Occam's razor."* This principle is so abused by the skeptics, "experts," and blind believers of establishment science that it has become farcical. In effect, it has become the lazy person's guide to explaining anything that doesn't fit the current paradigm. As I was reading the article on the Reich-Einstein experiment (*IE* #37), it occurred to me that Einstein misused Occam's razor in explaining the anomalous temperature rise. But the principle's rampant abuse is also seen in cold fusion, UFO investigations, and even social/political settings. While it may be valid in certain circumstances, if I were Occam (and I was still alive!) I would revise the principle ("the law of economy") with the idea that simple explanations often do an injustice to a potentially incredibly complex situation. What seems simple may just be a smokescreen that demands detailed investigation before clarity is reached.

2. *We need to move beyond the implication that science is static or absolute.* For all intents and purposes we have seen that the Second Law of Thermodynamics is of limited validity. Same for Newton's Laws, and as it seems, Relativity. (Dare I mention Quantum Physics?!) "Laws," if you want to use that term, are malleable, even in the legal sense. Even legal laws are not set in stone; this is why there are amendments to the Constitution. Science, real science, may be defined in many ways, but a good general definition is that science is an *evolving* set of *models* that help us understand our universe. When I hear (heard) the Sagans, Hawkings, Goulds, and others take current scientific "facts" and state them as if they are undisputable, timeless "truth," it makes me shake my head in dismay. The establishment press is adept at repeating this error, and the general public often follows as well. As history proves over and over again, to say anything of scientific origin is absolute or static is mind-bogglingly simplistic.

Thank you for your efforts. We are on the verge of great strides in understanding energy, consciousness, and spiritual evolvement that most of the establishment thinkers have yet to recognize. It will be exciting to watch and participate as this blossom unfolds!

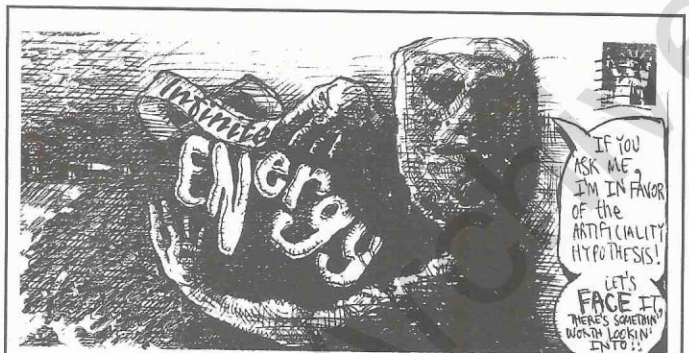
Michael Smith
Redmond, Washington

More *IE*-Inspired Art!

I just wanted to say thanks for printing my change of address envelope illustration in the Letters to the Editor section of *IE* #41. It was completely unexpected to see my artwork in print like that, especially since I had forgotten that I had even done it. My initial reaction was. . .that guy draws like me! But then, slowly, the realization that it was my own work started to creep in, as I saw my name printed underneath it and the memory of having done it started to return. It was stunning to see my artwork in print unexpectedly like that, but completely an honor and a privilege.

Normally I would not even have responded, I suppose, had it not been for the fact that a new illustration idea for my subscription renewal envelope had begun to take form, inspired by the Mars face article in *IE* #40 [reproduced below].

Aaron Ellsworth
Edinboro, Pennsylvania



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— Staff, *Infinite Energy*

Errata

In *IE* #42, the website of author Dietmar Rothe was misidentified in Reference 11 of his paper "Space and the Wave-Particle Enigma" (pp. 49-57). The correct web address is:

http://www.avilabooks.com/Book.htm

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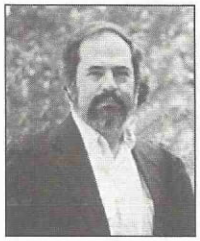
The Corruption of Physics

by Eugene F. Mallove, Sc.D.



Some may regard the extremely difficult birthing that cold fusion has been experiencing for the past thirteen years as an ordinary, expected, and even desirable obstacle course for the newly emerging physics paradigm of low-energy nuclear reactions. "Boys will be boys," so to speak; what cold fusion has been experiencing is just the natural and healthy conservatism in the process of science.

In my view, the situation is quite the contrary. The physics establishment's abandonment of the most rudimentary tenets of science during the cold fusion war suggests a much deeper problem for the physics that emerged during the twentieth century: 1) A deep-rooted corruption on every level, beginning with the fanatical zeal of its defense of supposedly sacrosanct dogma; 2) The virtual stranglehold over the scientific and general media that the physics establishment maintains on any departures from its wishes; and 3) The concentration of power in the form of massive white-collar welfare for indefensible research programs that seek not to expand our scientific horizons, but to circumscribe them.

For an illustration of the corruption of physics, which is at once sad and humorous, examine the cover story in *Discover* magazine, April 2002, "Where Did Everything Come From?" Right near a red glass marble ("actual size") picture of "The universe at about 10^{-34} seconds" is this message of received wisdom from the Physics Establishment: "The universe burst into SOMETHING from absolutely NOTHING—zero, nada. And as it got bigger, it became filled with even more stuff that came from absolutely NOWHERE. How is that possible? Ask Alan Guth. His theory of inflation helps EXPLAIN EVERYTHING." [Capitals are *Discover* magazine's emphasis.]

Professor Guth of MIT is the physics establishment *wunderkind* of the month, who, the article hints, is very close to winning a Nobel Prize for originating ideas of "cosmic inflation." These inflated ideas help prop up another of Physics' indefensible dogmas, the Big Bang. (In the March 2002 issue of Dr. Tom Van Flandern's *Meta Research Bulletin*, one finds "The Top 30 Problems with the Big Bang"—as expected, not a hint of any of those concerns in the *Discover* article.) An especially provocative and dogmatic prediction of Guth is highlighted by *Discover* author Brad Lemley, ". . .any cosmological theory that does not lead to the eternal reproduction of universes [from our own] will be considered as unimaginable as a species that cannot reproduce." So "science" has come to this: An actual-size picture of the our universe at 10^{-34} seconds on the cover of a Disney-owned publication (how appropriate!) and the dispensed certainty by guru-of-the-month Guth that this red marble is only one of an infinity of universes that eternally bud-off from our own. Take it from Guth, it's the truth.

In recent issues, *Infinite Energy* has tried to show that rational critiques of the dogmas of relativity, quantum mechanics, and thermodynamics exist, which could mean that modern physics is nothing but a house of cards teetering on the brink of collapse. (That's precisely what I think it is, but let's give this *deflationary experiment* enough time to run its course.) In this issue, Donald Hotson's review of the history of the Dirac's equation, a possible major wrong turn in physics that occurred in the 1930s, is in our tradition of airing rational critiques about issues of overarching importance to new sources of energy. Ditto for our literally "demonic" examination of the many flaws in the Second Law of Thermodynamics. Not to forget our coverage of what was breaking news in our last issue, the sonofusion experiments at Oak Ridge National Laboratory. These have appeared in *Science*, the wishes of the Physics Establishment notwithstanding. No more perfect example of the deep corruption of physics could be found than the anti-sonofusion hysteria, which erupted on this occasion. So let's examine it in more detail.

Science magazine's publication of the Taleyarkhan *et al.* paper, "Evidence for Nuclear Emissions During Acoustic Cavitation" and associated commentary in its March 8, 2002 issue provoked unusual criticism and controversy—even before the actual appearance of the article. (See our coverage in this issue, pp. 8-11.) It is reminiscent of what followed the March 23, 1989 announcement of cold fusion by Fleischmann and Pons. Actually, after the Utah announcement there was a relatively polite "grace period" of a few weeks (at least in most public pronouncements) before the behind-the-scenes rabid critics came out with guns blazing and accused Fleischmann and Pons of incompetence and/or fraud—a stigma which has lasted more than thirteen years.

There was no grace period this time, even though the subject of the *Science* paper makes no claims of cold fusion (though it may well be that these results reflect, in part or in whole, some cold fusion reaction connection). The authors discuss their evidence for neutron emissions and tritium elevation above background in the context of D + D hot fusion occurring at elevated temperature within the collapsing cavitation bubbles.

The vehemence of the attack on this table-top fusion claim surprised many people, including some in the cold fusion field. After all, why should a new potential *hot* fusion method be criticized? As a long-time participant in the cold fusion war, I'd like to suggest some of the "whys" for the vicious attacks that have already occurred—not necessarily in order of their relative importance in the current furor; there is surely much overlap and interaction among them.

• Similarities to Cold Fusion

This has to be a very big factor. The current "*Science*-sonofusion" (to distinguish it from other sonofusion efforts, especially in the cold fusion community) is "table-top" in size, was done in a deuterated liquid (acetone, not heavy water), and is of relatively modest expense—just like cold fusion; the *Science*-sonofusion is being purveyed mainly by nuclear engineers, not plasma physicists (cold fusion was prompted by chemists, not physicists), and thus outsiders to the hot fusion/physics community; there is evidence of neutron emission and tritium—the early and continuing claims in cold fusion. Because of these similarities, the critics—who were part of the anti-cold fusion camp already—feared and will continue to fear a possible new openness to classical cold fusion by the media and from funding sources. In the general confusion of the recent events, this possible confusion of *Science*-sonofusion with cold

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fusion has already occurred (*e.g.* the headline in the UK *Sunday Times* of March 3, 2002). It may not actually be a confusion; coherent cold fusion-like processes may be at work in *Science*-sonofusion, at least in part. After all, the process is occurring in the environment of sonoluminescence (SL), which was a mysterious process to begin with. There is no generally accepted explanation for the light emission and coherent processes that have been implicated in SL. The late Nobel Laureate Julian Schwinger, a cold fusion theorist, had suggested similarities between cold fusion and sonoluminescence in "A Progress Report: Energy Transfer in Cold Fusion and Sonoluminescence" [a lecture at MIT, November 11, 1991; reprinted in *Infinite Energy*, March-April 1999].

• Impact on Hot Fusion Funding

There is nothing worse for the hot fusioneers than any suggestion that alternative paths to fusion energy might reasonably be considered. Alternative paths, such as cold fusion or *Science*-sonofusion, might mean losing some hot fusion funding to the alternative modes—or a cancellation of hot fusion projects generally. Hundreds of millions of dollars per year in hot fusion funding are at stake. Furthermore, in the immediate time period the hot fusioneers have been orchestrating to get the U.S. back into the multi-billion dollar ITER hot fusion project. This news about sonofusion in a very prestigious publication, *Science*, is the last thing the hot fusioneers wanted anyone to hear about at this time.

• Intellectual Arrogance of Physicists—NIH (Not Invented Here) Syndrome

Cavitation bubbles, sonoluminescence, postulated very high temperatures in these collapsing bubbles, and even the possibility of fusion occurring in cavitation bubbles has been around since at least the early 1990s. Therefore, the physicists who are attacking *Science*-sonofusion must have given this possibility some thought, and even some testing from time to time. They evidently concluded that it was not a feasible process—on theoretical or experimental grounds—and now someone comes along to tell them that there is a way to make it work! This is a challenge to their vaunted intellects—as it was in 1989. "Why didn't we think of that? Wait, it's got to be a stupid/invalid idea because we didn't think of how to do it! Now let's prove that it is wrong and can't be real. We'll be heroes!"

• Suspicions of "Pathological Science"

The scientific community has been conditioned by the likes of CSICOP (Committee for the Scientific Investigation of Claims of the Paranormal) and the bashing of cold fusion to look at any very surprising results in terms of the possibility that the new claim is "pathological science"—what they believe cold fusion to be. They thus fear a new outbreak of this alleged disease.

• The Cheerleader Effect

The scientific establishment has its boosters, spokesmen, and cheerleaders. Unfortunately for the American Physical Society, it has one of the biggest and most ignorant mouths in science on its web page—pseudoscientist Robert Park with his weekly "What's New" column. So intent was Park to lead the troops against the *Science*-sonofusion claim, that he jumped the gun on the March 7 news embargo by *Science* and on March 1 revealed the emerging story and the behind-the-scenes attempt to kill it. Park both follows and leads. He gathers faulty information from sources, like the late Douglas Morrison or the hot fusion people in this instance, and then spreads it around. Park's groupies then use this as a signal to move in for the kill against the offending new idea. Journalists are especially susceptible to this. One monkey sees Park spouting off in Outlet A and soon Outlet B and many other outlets have other physicist monkeys chiming in.

• Fear of Errors and Mistakes

Closely related to the crackpot idea of "pathological science" as a major ailment of science that must be guarded against, is the creeping notion that it is not OK to make errors in science. There is an imagined "contest" going on to make sure that no scientific paper published by *Science* or *Nature* is wrong in some fundamental way. This, of course, is completely against the spirit of true science. The history of science is permeated by errors that have taught us how to move forward in the right direction. Furthermore, many revolutionary concepts that were initially roundly criticized as error, later became acknowledged as true. Still, the message of this history is not getting through to the general community and there is a palpable fear of publishing something that might be wrong—and thus open to attack by science-bigot cheerleaders like Park.

• Peer Review = Sneer Review

The fact that this *Science* paper was almost killed by its opponents, and even after it came out is being attacked for its very existence, is a good case study for the scientific community that its so-called "peer-review" system has completely broken down—if it ever had been a truly legitimate process. "Peer review" today accomplishes two things: A) It fixes many minor and/or major mistakes in articles in an accepted field of study (and that part is to the good) and B) It completely weeds out topics that are forbidden, *e.g.* cold fusion, while allowing such "acceptable" discussions as how to create baby universes and whether the universe has 10 or 26 dimensions.

• Fear of Loss of Reputation

Much is at stake today in the scientific community in being always right with such opinions as "cold fusion is nonsense," "homeopathy can't work," "all UFO reports are bogus," etc. Thus, as soon as any purported evidence comes to light that hints directly or indirectly that the purveyors of CSICOP-like myths might be in for a big crow-eating, out go the defensive statements to the press. The most ludicrous one so far in this *Science*-sonofusion affair is from cold fusion-basher Gary Taubes: "If history is any indication, just the existence of this kind of brouhaha and the criticism from very competent experts is good evidence that the results are just dead wrong. And, if it's dead wrong, then *Science* probably shouldn't have decided to publish it." (*USA Today*, March 5, 2002)

• "Good Scientists" Proved It Wrong Already

As soon as the Chief Cheerleader put out the notion that "good physicists with much better equipment" can't seem to find the claimed *Science*-sonofusion effect, this is taken as encouraging news to the attacking troops. More groups form to perform hatchet jobs and receive new honors for helping to slay "pathological science." Never mind that the first group of "good scientists" did not measure tritium—a key observation in the *Science* paper!

• Fear of "Free Energy"

This is the basic reason that all laboratory claims of a new kind of robust energy that could have a vanishingly small "fuel" cost, or actually zero fuel cost, face an uphill battle. The idea that energy could become free is as alien a concept to Corrupt Physics as the notion in the fifteenth century that celestial lights might be other worlds. Anything that touches the idea of free energy is rejected by society at an extremely primitive level—a knee-jerk reaction carefully nurtured by the Physics Establishment. There is a subconscious understanding by everyone of what free energy would mean, even if it hasn't been thought out carefully by each individual. The average mind recoils from it; it is too unsettling. People who want business as usual aren't interested in hearing that their world could turn upside down and be unrecognizable. "It's too good to be true, therefore it can't be true." ❑❑❑

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The Table-Top Fusion Upheaval

Eugene Mallove

"Table-Top Fusion" is shaking up the world of physics again, much as it did thirteen years ago with the announcement of cold fusion at the University of Utah. As the last issue of *Infinite Energy* went to press in early March, we reported the breaking development of new sonofusion claims reported in the March 8 issue of *Science* magazine. Researchers at Oak Ridge National Laboratory and elsewhere, in what are being widely called "table-top fusion" experiments, published evidence for neutron emissions and tritium production in a deuterated liquid organic material (acetone—C_3D_6O) activated ultrasonically (19.3 kHz) to produce cavitation bubbles.

The *Science* coverage began with an unusual editorial by *Science* Editor-in-Chief Donald Kennedy, "To Publish or Not to Publish" (p. 1793). In describing the careful review process for the controversial paper, Kennedy wrote, ". . .*Science* received communications from two distinguished scientists in the field, raising objections to the paper and urging that we reconsider our plans to publish it. And the matter become even more public on March 1, when Robert Park issued an airy, premature dismissal from the American Physical Society." (Park's "What's New" column of March 1, "Bubble Fusion: A Collective Groan Can Be Heard," included this comment: "Although distinguished physicists, fearing a repeat of the cold fusion fiasco thirteen years ago, advised against publication, the editor has apparently chosen not only to publish the work, but to do so with unusual fanfare, involving even the cover of *Science*. Perhaps *Science* magazine covets the vast readership of *Infinite Energy* magazine.") Editor Donald Kennedy continued his editorial, "By this time, it had become clear that a number of people didn't want us to publish this paper." Kennedy concluded, "What we ARE very sure of is that publication is the right option, even—and perhaps especially—when there is some controversy."

Park's fears aside, the article was not promoted on *Science's* cover, though there was a photo of the reaction chamber with the phrase "A star in a jar," on the table of contents. The coverage included the technical article itself ("Evidence for Nuclear Emissions During Acoustic Cavitation," R.P. Taleyarkhan, C.D. West, J.S. Cho, R.T. Lahey, Jr., R.I. Nigmatulin, and R.C. Block, *Science*, Vol. 295, March 2002, pp. 1868-1873). And there was a technical commentary ("Evidence for Nuclear Reactions in Imploding Bubbles," F.D. Becchetti, p.1850). Finally, *Science's* "News of the Week" section (p. 1808) devoted almost two pages to the waves of controversy surrounding the paper's publication. This latter journalistic coverage by Charles Seife included the appalling, ignorant statement, ". . .the scientific community is still wiping egg off its face from the 1989 debacle involving so-called cold fusion, in which some researchers erroneously claimed to have seen fusion catalyzed by a lump of palladium metal." The news coverage revealed, however, that two of the 1989 DOE cold fusion panel negativists, Princeton's William Happer and Richard Garwin of IBM's facility in Yorktown Heights, New York, were at it again, orchestrating against the paper's publication. Happer was reported to be trying to save *Science* from another "fiasco." Said Happer to *Science's* Seife, "I saw it happen with cold fusion. If we're really unlucky, Dan Rather will talk about it on the [CBS] evening news and intone how, providentially, the energy problem has been solved. We as a community will look stupid." In truth, it would be tough to find a more stupid science bureaucrat than hot fusioneer Happer, whose repugnant remark about Fleischmann and Pons lives in infamy: ". . .just by looking at them on television you could tell they were incompetent boobs."

Taleyarkhan *et al.* employed a neutron source to help create (*i.e.* nucleate) the cavitation bubbles, and make them much bigger (on the order of a millimeter diameter, growing from the 10 to 100 nanometer nucleation bubbles) than they would have been with ultrasonic energy input alone. And, it is important to understand that the piezoelectric transducer used by these researchers was *outside* the sonofusion cell, so no metal surfaces were in contact with cavitating bubbles, unlike sonofusion carried out in the cold fusion field. The authors did not attempt to measure excess heat (no surprise), because the entire context of their article was that multi-million degree temperatures were being created by the collapsing cavitation bubbles, and thus mini-*hot* fusion of deuterons was allegedly being accomplished. They did not report any helium measurements being performed.

The anomalous elevated ratio of tritium to neutron production reported in the article, which are already being dismissed by critics outright as indicating an experiment flaw (just as they were with cold fusion in 1989), has long been a known characteristic of cold fusion systems. But in cold fusion the anomalous ratio is up to 10^8, while in the present Oak Ridge experiments the tritium to neutron ratio is on the order of 10 to 100, but may actually be only 1.0, depending on how the analysis is performed. Two hot fusioneers at ORNL, Dan Shapira and Michael Saltmarsh, who *claimed* to have attempted the experiment properly prior to the article's release, said that they did not observe the 2.5 MeV hot fusion neutrons from the D + D reaction. Taleyarkhan *et al.* sharply disagreed with their analysis, but in their article referred to this non-peer-reviewed work. Moreover, in true pathological skeptic fashion, Shapira and Saltmarsh made no tritium measurements—thus artificially truncating half of the experimental claims! On the basis of this flimsy work, Oak Ridge National Laboratory management, acting in concert with Happer and Garwin, almost succeeded in getting *Science* to reject the article.

The *New York Times* of March 5 led on page A20 with a highly skeptical article, but the *London Sunday Times* (March 4) was much more upbeat and even quoted Martin Fleischmann. The story spread through dozens of media outlets. *The Economist* (March 9) began its coverage with disgraceful nonsense: "As parents scare their children with stories of ghosts and ogres, so professors scare their students with stories of Fleischmann and Pons. . .For a few weeks people dreamed of limitless clean power. But other researchers failed to replicate their results and

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it was clear a mistake had been made. Dr. Pons and Dr. Fleischmann were disgraced, and now labour in obscurity."

The matter to celebrate the most in these *Science* articles is the apparent discovery of yet another particular system for producing fusion reactions. And we certainly celebrate that the experiments are, indeed, "table-top"—just like most cold fusion experiments. Of course, the work reported in *Science* needs to be reproduced in its particular form, just as cold fusion experiments had to be and were reproduced, repeatedly. But on first examination, the work appears to have been done very thoroughly. It is immediately apparent that sonofusion work carried out in the cold fusion/low energy nuclear reaction (LENR) field, although not referenced by these authors, can provide significant support in both experimental and theoretical aspects. We imagine that the authors were not aware of much of this work.

Perhaps the appearance of the *Science* articles will cause scientists, technologists, and officials to reconsider their previous impression of other fusion technologies, including the much maligned cold fusion science and its emerging technology. Cold fusion/LENR has been under research and development for some years, since being prematurely dismissed by a egregiously flawed and rush-to-judgment DOE report in 1989.

The *Science* critique by Bechetti was well done and will likely anger the hot fusioneers, because it puts this work too much into the same context as energy generation via tokamaks and big lasers, something they do not want to hear. As usual, they want all DOE resources concentrated on *their* well-funded projects. And, I noticed that Becchetti did refer to a paper in 1990 of a supposedly failed "table-top" experiment (likely one of the "failed" cold fusion replication attempts, but I do not have the specific paper referred to) in which he said he participated. He and *Science* are to be roundly criticized for referring to an early cold fusion era experiment, while not properly mentioning that numerous other highly positive experiments with repeatable results—especially at tritium generation (*e.g.* by Dr. Tom Claytor at Los Alamos National Laboratory), but also neutron generation—have been done in cold fusion. It must be recalled that in June 1990, *Science* magazine produced a virtually slanderous attack by Gary Taubes against the work of cold fusion researchers at Texas A&M University, suggesting that fraud was the likely explanation of the tritium findings in cold fusion experiments. That this past poor journalism and continuing tritium findings in cold fusion continue to be ignored at *Science*—except when an alleged *hot* fusion explanation is given—is intellectually dishonest.

There is an effort throughout the March 8 technical paper to put the observed reactions into the context exclusively of *hot* fusion. But the experimenters were still unable to get the gap between neutron counts and tritium measured to fall much below a single order of magnitude difference. The authors do much hand-waving to say that this might be "explained" by various measurement errors and inefficiencies. Indeed, cold fusion experiments show many times a factor of 10—up to a 100-million ratio of tritium to neutrons when tritium is found. And, cold fusion experiments have proved that the birth of the tritium can be *cold*, not *hot*. If it had been hot (energetic), as in tritium formed by the D + D hot fusion reaction, 14 MeV hot fusion neutrons (from T + D collision reaction) would have been seen and they are not seen, *e.g.* what Claytor *et al.* at Los Alamos National Laboratory have determined.

Because of the uncertainties in this *Science* paper data, it is not possible to determine whether this is fully mini-hot fusion, or some mixture of cold fusion and hot fusion. That will come later. The most important matter is that this article may get more people thinking again about alternative ways to do fusion. This inevitably will bring up the huge body of cold fusion literature that has been ignored by these authors and *Science*. It is too bad that it has to happen this way. It would have been better if proper coverage by *Science* had been occurring all along. Many cold fusion people long ago gave up even submitting to *Science*. They publish in the *Japanese Journal of Applied Physics*, *Physics Letters A*, and *Fusion Technology*, among other journals, including *Infinite Energy* magazine. The hot fusion people will continue to do their best to trash this new table-top work, especially because it is in the context of ongoing work that they well know is occurring worldwide on cavitation-induced fusion. They helped kill off more widespread interest in electrolytic fusion, but it will be much harder for them to kill off these kinds of sonofusion experiments, especially now that they are documented in a very visible publication.

Sonofusion: The Real Background

Sonofusion (and sonoluminescence) is an area in which *Infinite Energy* has published since its inception in 1995. Our first issue, March/April 1995, had Roger Stringham (now of First Gate Energies, Inc.) on the cover, cradling his sonofusion reactor. The cover story, "A 'Micro-Fusion' Reactor: Nuclear Reactions 'In the Cold' by Ultrasonic Cavitation," was by Tom Benson (Vol. 1, No. 1, pp. 33-37). There have been many other pieces, notably:

❒ "Cavitation in D_2O with Metal Targets Produces Predictable Excess Heat," Roger Stringham, John Chandler, Russ George, Tom Passell, and Dick Raymond, *Infinite Energy*, Vol. 4, No. 19, April-May 1998, pp. 41-44.

❒ "A Progress Report: Energy Transfer in Cold Fusion and Sonoluminescence," Nobel laureate Julian Schwinger (Reprint of his November 11, 1991 lecture at MIT), *Infinite Energy*, Vol. 4, No. 24, March-April 1999, pp. 81-83.

In more recent issues of *Infinite Energy* since November 2000 (Nos. 35-41), NERL's Manager, Kenneth Rauen, and I have chronicled our experience with Roger Stringham's sonofusion reactor, and our smaller modified reactor derived from it. The primary purpose of this work has been to identify the primary and most desirable signature of cold fusion/low energy nuclear reactions—excess heat—but we will now also look for tritium via liquid scintillation counting with some of our ultrasonically activated heavy water solutions saved from past experiments. Dr. McKubre's group at SRI International recently worked with one of our titanium target reactors to look for possible helium production, but has not found any convincing helium evidence. Roger Stringham *et al.* claim already to have found helium and other nuclear evidence in their sonofusion devices, in addition to observing melting under heavy water of normally high melting point metals.

Statement About *Science* Magazine Bubble Fusion Papers

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Donald Kennedy[1] is to be congratulated for deciding to publish and profile[1-3] the article by Taleyarkhan *et al.*[4] in the

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March 8 issue of *Science* magazine. Faced with controversial opinions,[1] he decided to publish a controversial article as well as commentaries[2-3] about it, despite harsh criticism.[3,5] Charles Seife[3] should also be congratulated for presenting background material concerning the relevant facts about both sides of a potentially spectacular scientific discovery, involving room, or near-room temperature nuclear fusion.

It is unfortunate (but understandable) that Charles Seife missed a number of key points about the underlying dynamic of the debate. Part of the problem is sociological: chemists and nuclear engineers view the world differently from nuclear physicists. Part of the problem is more basic. Nuclear physicists have ignored important effects (with good reason, until 1989) involving potentially non-local effects associated with electromagnetism (EM) in most applications of nuclear physics. The problem is that non-local EM effects can make a big difference in the way nuclear fusion begins and ends, provided an appropriately constructed procedure is developed.

Nobel Laureate Julian Schwinger's view[6] of the situation provides an instructive lesson. The father of the Rarita-Schwinger equation, which is used to describe the underlying building blocks (Deuterons, D) of nuclear fusion, as well as of quantum electrodynamics, which provides the basic framework for most theories of interaction, Julian Schwinger recognized that coherence, driven through electromagnetic effects, could significantly alter the possible ways that nuclear fusion could occur. Thus, implicitly, throughout, he made the point that EM potentially can couple disparately different length scales, and for this reason he replaced the use of intuitive ideas about localization in certain circumstances with more precisely-understood ideas associated with coherence. These can lead to non-local (more wave-like) features (for example, in the Mossbauer effect) that are implicit in the EM interaction,[6] in which momentum is shared by many locations (as in a Bose Einstein Condensate or in the behavior of a periodically ordered solid) instantly. However, although he pointed this out, up front, no one listened. Part of the problem is that implicit in this view is the idea that phenomena can become non-local in nature. Although this is known to occur in solids, nuclear physicists for the most part have not been prepared to accept the possibility that it can occur in nuclear fusion, despite the fact that implicitly it can occur is already known.

Part of the problem appears to be the result of a breakdown in communication. Since the 1930s, after chemists discovered a cornerstone of nuclear physics (nuclear fission), a gradual decline in communication between chemists and nuclear physicists has taken place. An important reason for this involves length-scale: Nuclear reactions appear to only occur when isolated particles collide at a particular location where particles are separated from each other by distances that are as much as 100,000 times shorter than when they interact in normal chemical reactions. Thus, chemists and nuclear physicists have assumed they are dealing with such completely different phenomena that they have believed that what they study can not possibly be related.

The key point of confusion has involved the role of EM in nuclear fusion (NF). Most nuclear physicists believe NF occurs when EM alters reactions through particle-particle collisions at isolated locations, through "tunnelling" effects, associated with a simplified picture of the EM interaction. For this reason, nuclear physicists ignore more subtle, potentially longer-range effects that can be triggered in dynamically changing environments, which very easily can be present in solids (as in the case of cold fusion) or in cavitating bubbles (as in bubble fusion). In both situations, as Schwinger pointed out,[6] coherent forms of interaction involving EM can occur. For this reason, many of the intuitive ideas that nuclear physicists have about NF need not be valid.

An important question associated with both cold fusion (CF) and bubble fusion (BF)[4] is whether or not it is necessary that comparable numbers of tritons N_t and neutrons N_n be produced. Provided non-local EM interactions only occur over sufficiently long length scales, through processes that proceed sufficiently slowly, the effect of EM can be treated statically, and its effect on the nuclear interaction through dynamical forms of coupling can be ignored. Then, it is true, effectively, with respect to the nuclear reaction, the effect of the EM interaction on the makeup of the final state becomes inconsequential, and $N_t = N_n$.

But in the BF work,[4] N_t is at least an order of magnitude greater than N_n,[4] and it could be as much as two orders of magnitude greater. In fact, in cold fusion, not only is the disparity between N_t and N_n significantly greater, the reason for the disparity is well-understood.[7] It occurs because for this case, the dominant reaction, $D + D \rightarrow {}^4He$, involves non-local EM coupling.[8] For this reason the amounts of neutrons or tritons that are produced are usually statistically insignificant, although both experimental evidence and theoretical explanations exist for understanding how cold (*i.e.* low energy) tritons can be produced.

In fact, in more general terms, when non-local EM effects become important, the normal assumptions about NF (such as the requirement that interacting D's have high enough kinetic energy to circumvent the Coulomb barrier) need not apply. In particular, for example, for D + D fusion to result in the production of ^4He, each of the interacting D's must be indistinguishable from the other on length scales associated with conventional EM interaction.[8] Because at high incident energy and momentum this condition is rarely met, ^4He is rarely produced in NF. However, at lower values of the incident momentum, not only do the underlying features associated with our understanding of conventional $D + D \rightarrow {}^4He$ at higher momentum require that this symmetry be present, the fact that the dominant excess heat reaction in electrolytic CF occurs in this manner implies that this requirement is being satisfied when the incident D's have lower momentum.

An important point of confusion is that although $D + D \rightarrow {}^4He$ occurs relatively infrequently, the reason for this is that this particular reaction involves significant coupling between the nuclear and EM forces. Because in single-bubble cavitation an acoustical field can be used to produce precisely tuned, time-varying EM radiation,[6] it is plausible that the coupling between the boundaries of the bubble and its potentially interacting D's may also result in significant EM coupling, in a dynamically-driven fashion.

Especially at close separation, when 2 D-nuclei begin to overlap, it is possible to view the 2D state as an excited state of a ^4He nucleus. Then, significant coupling to a dynamically changing EM field (as pointed out by Schwinger[6]) can occur. This suggests that since in the experiment[4] fast (~14.1 MeV) neutrons (n's) are introduced to foster bubble

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growth, it is entirely possible that on occasion particular n's collide with a 2D initial state configuration that resembles a ^4He nucleus. If this happens, provided this excited state nucleus effectively recoils in an appropriate manner, it may be possible to create a reverse D-t fusion reaction, in which $^4He + n \rightarrow D + t$. In this way, one can see how effects that are well-known can be used to explain the potentially anomalously high ratio of tritons to neutrons.

An important point is that regardless of whether or not the details associated with this argument are correct, the possibility that the reaction could occur is associated with potentially significant coupling with the EM field. Over the years, in CF it has also been found that the EM field not only can couple to potentially interacting D's but that it can do so in a coherent fashion, without high energy particles being released. Thus, the fact that N_t does not equal N_n in bubble fusion may be related to the fact that the dominant reaction in cold fusion involves the production of ^4He.

With hindsight, it's obvious that confusion about potential effects associated with coherent coupling to the EM field could lead to situations in which high energy particles would be inhibited, in CF. It is also obvious that because of the highly non-linear coupling to the EM field that occurs in many of the electrolytic experiments, under certain circumstances the process of triggering the associated forms of interaction can be closely associated with changes in the local environment in the electrodes. This led to considerable confusion in 1989. Additional confusion resulted because at that time most nuclear physicists adopted the conventional view of the potential role of EM, and the impossibility of coherence and related factors altering the relevant forms of reaction.

Further compounding this confusion was the fact that cold fusion claims were made simultaneously by chemists (Martin Fleischmann and Stanley Pons), followed by counter-claims by nuclear physicists (Steven Jones and coworkers), involving very different phenomena. A second, key source of confusion was the assumption that the claims were related when they were not. Thus, at an early stage, as a consequence, the dynamic of the debate (or lack of debate) rapidly became unscientific.

A tragic aspect of the episode is that new vehicles for communication emerged (the internet and fax machines), and the press also became involved. As a consequence, unprecedented confusion about the various claims escalated. It is unfortunate that even at this late date, Charles Seife is neither aware of the underlying dynamic, the relevant experimental situation, or (from all appearances) the fact that the debate remains unresolved. Potentially more tragic is that he provides quotations from individuals who either are ignorant of what has transpired during the last thirteen years or have deliberately decided not to disclose new information about the associated field.

In contrast to the situation described by Seife,[3] where cold fusion not only is not taken seriously, but where through apparent fear about potential embarrassment, the subject continues to be ridiculed, as guest editor of a recent volume of an *Ethics in Science Journal*, I asked a number of journalists, editors, and scientists to re-examine what happened in the cold fusion controversy.[9] Contrary to the assertions made by Seife[3] about this subject, in fact, the consensus was that no consensus exists because meaningful dialogue about cold fusion ended very early. This occurred partly because of confusion that resulted from the very strong opinions that were expressed at an early stage in the controversy. But it also occurred because arguments and claims were not adequately reviewed and discussed prior to their being announced in the press.

However, remarkable as it may seem, it is also true that a number of the more important CF claims, made by the chemists, may very well be true, despite the fact that most nuclear physicists dispute them. An important point involves perspective: nuclear physicists and chemists are different. Chemists pay attention to fine details involving the environment of a particular reaction that may include important long-range EM effects that are often missed (or dismissed) by nuclear physicists.

It also is not true that the "cold fusion" field has been dismissed, although this seemed to be the case, following a raucous, unwieldy meeting of the American Physical Society (APS) that was held in Baltimore on May 1, 1989. In fact, on March 22, 2002 a session was held concerning cold fusion at a meeting of the APS, and others have been held since 1999. At this session, well-defined experiments, based on well-defined protocols, were discussed. If Charles Seife had covered the debate at that time in an as even-handed manner as he did in his March 8 article concerning bubble fusion, it would have greatly helped to eliminate ongoing confusion about an important, contentious area of scientific debate.

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Can We Capture Maxwell's Demon?

Eugene Mallove

James Clerk Maxwell's Demon has haunted us for more than a century. It is the idea of a microscopic intelligence or "demon," who could sort fast-moving gas molecules from slower ones and thus create, for small or zero energy, the separation of an initially uniform temperature medium into a hot and a cold zone. This thermal separation could then be used by a heat engine or a thermoelectric process as a source of energy, tapping the natural movement from hot to cold—thus, getting infinite energy from heat in the environment. But how to create or "capture" such a demon?

The "impossibility" of such a macroscopically effective Maxwell's Demon has been codified in the various statements of the Second Law of Thermodynamics. Yet there is much evidence that this "Law" is yet another dogma of ancient nineteenth and twentieth century physics that will not stand. Almost before the ink of the infamous Second Law had dried, there were those, such as Nikola Tesla, who challenged it. Here is what Tesla wrote in 1900 in his famous popular essay, "The Problem of Increasing Human Energy" (*Collier's* magazine, 1900):

> Some new way had to be discovered which would enable us to get more energy. There was enough heat-energy in the medium, but only a small part of it was available for the operation of an engine in the ways then known. . .I was vainly endeavoring to form an idea of how this might be accomplished, when I read some statements from Carnot and Lord Kelvin (then Sir William Thomson) which meant virtually that it is impossible for an inanimate mechanism or self-acting machine to cool a portion of the medium below the temperature of the surrounding and operate by the heat abstracted. These statements interested me intensely. . .
>
> Could we artificially produce such a "sink" for the energy of the ambient medium to flow in? Suppose that an extremely low temperature could be maintained by some process in a given space; the surrounding medium would then be compelled to give off heat, which could be converted into mechanical or other form of energy, and utilized. By realizing such a plan, we should be enabled to get at any point of the globe a continuous supply of energy, day and night. . .Here then was an idea which, if realizable, afforded a happy solution of the problem of getting energy from the medium. But was it realizable? I convinced myself that it was so in a number of ways. . . can we produce cold in a given portion of the space and cause heat to flow continually? To create such a "sink" or "cold hole," as we might say, in the medium, would be equivalent to producing in the lake of space either empty or filled with something much lighter than water. . .Having recognized this truth, I began devising means for carrying out my idea, and after long thought, I finally conceived a combination of apparatus which should make possible the obtaining of power from the medium by a process of continuous cooling of atmospheric air. This apparatus, by continually transforming heat into mechanical work, tended to become colder and colder, and if it were only practicable to reach a very low temperature in this manner, then a sink for the heat could be produced, and energy derived from the medium. This seemed to be contrary to the statements of Carnot and Lord Kelvin before referred to, but I concluded from the theory of the process that such a result could be attained. This conclusion, I reached, I think, in the latter part of 1883, when I was in Paris, and it was at a time when my mind was being more and more dominated by an invention which I had evolved during the preceding year, and which has since become known under the name of the "rotating magnetic field."

Though Tesla's electrical technology has transformed civilization, we know of no "cold hole" engine plans bequeathed to us by him. But if historical experience with Tesla's other inventions are a guide (and not to forget "Fermat's Last Theorem"—proved after more than 300 years of doubt), we should be wary of assuming that Tesla did not have plans for a "self-acting engine," as he called it, which would have been a Demon-run engine for sure.

It happens that the history of Maxwell's Demon is more rich than is popularly known. We learn from the following essay by Andreas Trupp that a forgotten battle in late nineteenth century science pitted an important figure in organic chemistry, Josef Loschmidt, against Ludwig Boltzmann and James Clerk Maxwell. If Trupp's assessment of the mathematical argument by Loschmidt is correct concerning the temperature of a gas in a gravitational field, then a "perpetual motion machine of the second kind"—a *de facto* Maxwell's Demon is indeed possible, *by Maxwell's own admission*. The existence of even *one* such Demon should suggest the existence of many others.

Following Trupp's essay, readers should find very informative and exciting the contribution by self-taught chemist Kevin Varner, "Perpetual Motion in the 21st Century." Varner argues that the history of the investigation of osmotic pressure suggests that there are unexplained molecular phenomena that point to a concrete way in which a chemically-based Maxwell's Demon might be captured—through "tethered solute osmosis membranes," among other ideas.

These are by no means the only encouragements that one of Maxwell's Demons might be captured and tamed as an energy source. I have previously reviewed the rush-to-judgment character of the history of heat (see "The Mysteries and Myths of Heat: A Brief History of Hot and Cold," *IE* #37, pp. 9-11), which puts thermodynamic dogma in context. And there is other still-to-be-published experimental evidence of a more direct character, which others (including Ken Rauen of our New Energy Research Laboratory) have obtained, that Maxwell's Demons are indeed within range of capture. As with cold fusion and other "difficult to believe" phenomena, the day of the Demon's Denouement will be put off until the cage is securely locked and the Demon is outputting the "perpetual power" that we all seek. ❑❑❑

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Energy, Entropy: On the Occasion of the 100th Anniversary of Josef Loschmidt's Death in 1895:

IS LOSCHMIDT'S GREATEST DISCOVERY STILL WAITING FOR ITS DISCOVERY

Andreas Trupp*

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Abstract

In 1868, J.C. Maxwell proved that a perpetual motion machine of the second kind would become possible if the equilibrium temperature in a vertical column of gas subject to gravity were a function of height. However, Maxwell claimed that the temperature had to be the same at all points of the column. So did Boltzmann. Their opponent was Loschmidt, who died more than 100 years ago, in 1895. He claimed that the equilibrium temperature declined with height, and that a perpetual motion machine of the second kind operating by means of such a column was compatible with the Second Law of thermodynamics. Thus, he was convinced that he had detected a never-ending source of usable energy for humankind. In this article, new proof is given for the hypothesis that the equilibrium temperature is indeed a function of height. Thus, the 100th anniversary of Loschmidt's death shall be commemorated.

1. Introduction

When taking a look at any textbook on general physics, one finds the Second Law of thermodynamics formulated in two equivalent ways: "The total entropy of an isolated system can never decrease," and "A perpetual motion machine of the second kind is impossible." Today, the possibility of such a machine is just as inconceivable as is the assertion that a perpetual motion machine of the *first* kind might exist, which creates energy from nothing. A closer investigation, however, reveals that in the second half of the nineteenth century, a vivid debate was held among most reputable scientists on the possibility of a perpetual motion machine of the second kind. One of the most prominent propagators in favor of such a possibility was Josef Loschmidt, a name today well known even to schoolkids through the celebrated Loschmidt's number. A perpetual motion machine of the second kind would be capable of permanently creating, in a cycle, mechanical energy from just a single reservoir of heat. Thus, it would become possible, for instance, to convert the (dissipated) energy of heat contained in the air into mechanical energy without requiring a second, colder reservoir for the absorption of the refuse heat. Therefore, we would have available a source of energy that practically cannot be exhausted.

Loschmidt and Maxwell asserted that, if there were a stratification of temperature in a column of gas subject to gravity, the construction of a perpetual motion machine of the second kind would be possible. Up to the present day, no one has ever challenged that assertion. Maxwell believed that the temperature of the gas subject to gravity could not be stratified, but had to be the same at all points. He did not provide a special proof; rather, he intuitively extended his formula of velocities of molecules (which had been derived without regard to gravity) to a gas subject to gravity. Boltzmann sided with Maxwell. Moreover, he attempted to prove that the homogeneous temperature of a gas subject to gravity was ensured by the kinetic theory of gases. Loschmidt, however, was convinced that a perpetual motion machine of the second kind was compatible with the Second Law of thermodynamics. In that point, he disagreed with Clausius, Thomson, Boltzmann, and Maxwell. In particular, he believed that a perpetual motion machine of the second kind could be operated by means of a vertical column of gas, the temperature of which he claimed to be stratified.

In the twentieth century, Loschmidt's "revolutionary" assertion has hardly been paid any attention. It was mentioned by Stephen G. Brush in his 1978 book *The Temperature of History*. However, Brush does not give more than a clue when telling his readers that the dispute over the stratification of temperature between Boltzmann and Loschmidt provided a contribution to the debate on the Second Law of thermodynamics. No further details are offered.

In recent times (1995), it was Claude Garrod[1a] who tried to give a new proof of the uniformity of temperature. His arguments will be scrutinized further below.

2. On the History of the Second Law of Thermodynamics

Though the expression "perpetual motion machine of the second kind" was only introduced by Ostwald toward the end of the nineteenth century, the impossibility of such a machine had already been postulated as an axiom by Clausius in 1849 and by Thomson in 1850. Both Clausius and Thomson are considered the discoverers of the Second Law of thermodynamics.[1b]

One may wonder how Clausius and Thomson could so firmly believe in the truth of their axiom. The fact alone that such a machine had not been invented yet is not capable of explaining this conviction. In addition, one has to take into account that in the eighteenth century the opinion of the impossibility of a perpetual motion machine already prevailed, long before the theorem of the conservation of energy or the distinction between the first and the Second Laws of thermodynamics was advanced. A system of movable parts that, having come to rest once, would still be able to get into motion on its own, was simply inconceivable.[2] Of course, the eighteenth century scientists were not yet famil-

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iar with the kinetic theory of heat and did not realize that apparent rest turns into motion in the microscopic perspective. Such knowledge would have impeded the formation of Clausius' and Thomson's axiom.

Picking up reflections previously published by Carnot, Thomson declared the impossibility of a perpetual motion machine to be the foundation of his further investigations in the field of thermodynamics: "It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest surrounding objects."[3] From the impossibility of such a perpetual motion machine, one can easily infer the Second Law in a very general form, stating that a system will not depart from an attained state of equilibrium without interference from outside. Loschmidt accepted the Second Law in such a general form only (more precisely: he believed that the Second Law could be derived from the mechanical principle of least action). However, as emphasized by Loschmidt several times, it is impossible to invert the order of inference, *i.e.* it is not permitted to infer the impossibility of a perpetual motion machine of the second kind from the Second Law in its very general form:

> From these reflections one can draw the conclusion that the Second Law of thermodynamics can be inferred from the axiom of Clausius, "It is impossible to transfer heat from a colder to a warmer body without compensation," or from the equivalent one of W. Thomson, "It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects," that the inversion of that inference, however, is not permissible, because the content of the Second Law is more general than that of those axioms.[4]

3. Maxwell's (Hypothetical) Perpetual Motion Machine of the Second Kind

In the 1860s and 1870s, scientists dealt with the question of whether a gas subject to gravity in an insulated column has the same temperature at all points, or whether its temperature is a function of height. Maxwell was convinced that the temperature of a gas subject to gravity had to be uniform at all heights. Moreover, like Thomson and Clausius, he regarded a perpetual motion machine of the second kind to be impossible. However, he was very sure that if there were a gradation of temperature and if that gradation were different for different substances, a perpetual motion machine would be possible:

> In fact, if the temperature of any substance, when in thermic equilibrium, is a function of the height, that of any other substance must be the same function of the height. For if not, let equal columns of the two substances be enclosed in cylinders impermeable to heat, and put in thermal communication at the bottom. If, when in thermal equilibrium, the tops of the two columns are at different temperatures, an engine might be worked by taking heat from the hotter and giving it up to the cooler, and the refuse heat would circulate round the system till it was all converted into mechanical energy, which is a contradiction to the Second Law of thermodynamics. The result as now given is, that temperature in gases, when in thermal equilibrium, is independent of height, and it follows from what has been said that temperature is independent of height in all other substances.[5]

Modifying the device introduced by Maxwell, we erect one column (filled with gas) only, which is thermally isolated from its surroundings (see Figure 1). A vertical pipe (which is open at the upper end) is arranged in a way that it enters the column from its top. The material of the pipe consists of thin (horizontal) sections permeable to heat; each permeable section is followed by a section that is not permeable to heat, so that the number of permeable sections equals the number of impermeable ones. In the interior of that vertical pipe, a piece of metal (cylindrical in shape) suspended by a rope is allowed to move up and down. At the top of the column, that metal piece has the temperature of the upper part of the column. But while it is slowly lowered to the floor, the metal piece adopts the temperature of the gas surrounding it; it gathers tiny bits of heat at every height. Thus, it becomes hotter (without disturbing the phenomenon of a temperature gradation of the gas as such).

Finally it reaches the bottom (and the maximum temperature). Now it is towed back to the top in such a fast way that the temperature of the piece of metal has no chance of declining. In order to move the piece of metal up and down, no net work has to be spent: the expenditure of work when moving it upward is completely compensated by the gain in work when it is lowered to the bottom. The hot metal piece, however, can make water boil, and by the steam thus created a steam engine can be run. The refuse heat of that engine shall flow into the upper part of the column (not into the ambient).

One might be tempted to assume that the process of creating work has to come to a standstill as soon as the temperature of the column has reached uniformity (due to the extraction of heat at its bottom and the adding of refuse heat at its top). However, the starting point of our (and

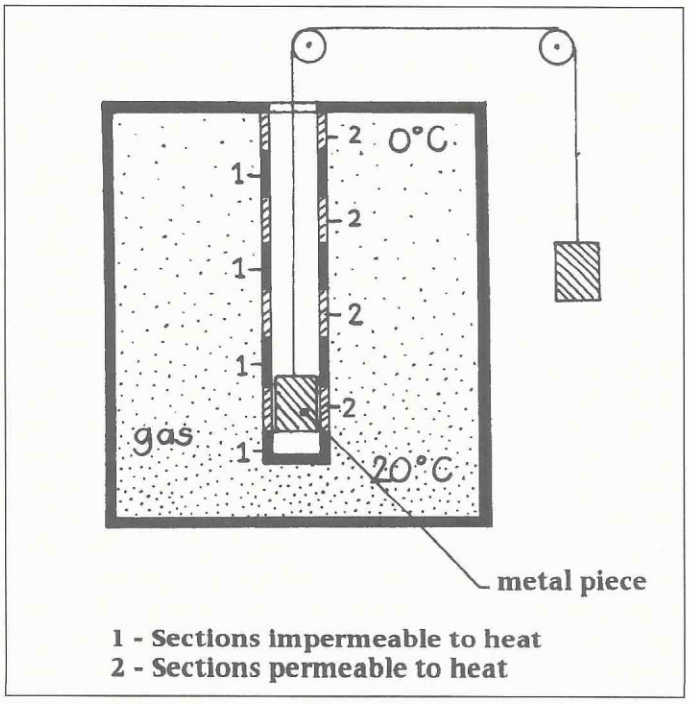

Figure 1. A revised version of Maxwell's perpetual motion machine of the second kind.

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Maxwell's) reflections was the hypothetical assumption (which Maxwell did not believe to be true in reality) that a uniform temperature of a column of gas subject to gravity is *not a state of equilibrium*. Hence, we have to conclude that the gas, left to itself during that break in work creation, will resume its state of temperature gradation. Then, the whole process can start again. The internal energy of the gas as a whole will thus be diminished and turned into mechanical work without a second heat reservoir.

Strictly speaking, Maxwell's original device only demonstrates that *differing* temperature gradients of two substances enable the construction of a perpetual motion machine of the second kind, whereas the modification gives proof of the possibility of such a machine already in the event of a temperature gradation existent in one single substance, that is, in the case of a temperature gradation as such.

4. A First Refutation of the Homogeneous Temperature in Gases Subject to Gravity (Confined to Ideal Gases)

Let us, for a little while, assume that the gas in a column is indeed of uniform temperature. The index 1 in the equations that follow stands for the bottom of the column. The function f (which we will try to determine) describes the distribution of the vertical components w of the velocity v_{tot} (=total velocity) of the molecules. N is the total number of molecules rising from the bottom per temporal unit. The norming constant of the function f is chosen in such a way that

$$\int_0^\infty f(w_1)dw_1 = 1.$$

The top of the column is a vertical distance of h from the bottom. There shall be no mutual collisions of molecules; there shall only be elastic reflections by the smooth inner walls of the column. Hence, those molecules with a vertical velocity w_1 of less than $(2gh)^{1/2}$ will not make it to the top. We shall call this velocity the critical velocity w_{crit}. Consequently, the number of molecules bouncing against the top per temporal unit is equal to

$$N\int_{\sqrt{2gh}}^\infty f(w_1)dw_1.$$

The other two components of velocity are left unaffected by gravity. With the gas being of uniform temperature T, the quotient of the number of molecules making it to the top divided by N must be identical to the exponential term found in the barometric formula (the barometric formula being $p = p_0\exp(-mgh/(k_BT))$, where p_0 denotes the pressure at the bottom and with k_B denotes Boltzmann's constant). Thus, in the case of a homogeneous temperature of the gas, we would have (as a starting point for determining the function f):

$$e^{-mgh/kT} = \frac{N\int_{\sqrt{2gh}}^\infty f(w_1)dw_1}{N\int_0^\infty f(w_1)dw_1}, \qquad \int_0^\infty f(w_1)dw_1 = 1. \tag{1a}$$

From (1a) follows:

$$\begin{aligned} &[F(w_1)]_{\sqrt{2gh}}^\infty = e^{-mgh/kT}, \\ &F(\infty) = 0, \\ &\rightarrow F(\sqrt{2gh}) = -e^{-mgh/kT}. \end{aligned} \tag{1b}$$

To elucidate: Because the exponential term on the right side of the first equation in (1b) is not a sum of two members, it is obvious that either $F[(2gh)^{1/2}]$ or $F(\infty)$ must equal zero. An exponential term can only be zero if the exponent approaches negative infinity. So $F(\infty)$ has to be identified as the term that amounts to zero. This allows us to state that $F[(2gh)^{1/2}]$ equals the negative exponential term of the barometric formula.

When substituting $(2gh)^{1/2}$ with w_{crit} on the left hand side of the equation (third line), and by substituting the terms g and h with the help of w_{crit} on the right hand side (w_{crit} equals $[2gh]^{1/2}$), we arrive at

$$\begin{aligned} &F(w_{crit}) = -e^{-\frac{m}{2kT}w_{crit}^2}, \\ &\rightarrow F(w_1) = -e^{-\frac{m}{2kT}w_1^2}, \\ &\rightarrow f(w_1) = \frac{m}{kT}w_1 e^{-\frac{m}{2kT}w_1^2}. \end{aligned} \tag{1c}$$

To elucidate: The first line of (1c) reveals that the variable w_1 (of which w_{crit} is just a special case) appears within the exponential term and only there (in the second power). Therefore, the first line can be generalized for all values of w_1. The outcome of this generalization is presented in the second line. From the second line, in turn, the third line can be derived by differentiation. The result achieved is identical to Maxwell's formula of distribution of velocities. The norming constant, which shall be called C_1, equals m/k_BT. It looks somewhat unfamiliar—this is due to the fact that the number of molecules bouncing against a plane per temporal unit, and not the number of molecules per unit volume, is counted.

Let our formula be subjected to a test. The average w-component of the molecules' kinetic energy within a thin layer of a thickness dz just above the bottom must equal $(1/2)k_BT$. If we came to a different result, our reasoning would contain an error: The thesis according to which the average w-component of the molecules' kinetic energy equals $(1/2)k_BT$ is derived from a set of well-corroborated physical laws and should hence be given preference over any other result derived from the assumption of a homogenous temperature of the heavy gas. The number of molecules within that thin layer dz is proportional to $1/w_1$ (at a given temporal rate by which the molecules rise from the bottom floor): the slower the rising molecules, the narrower the vertical gap between two consecutive molecules (which have identical velocities), and the higher the density of that class of molecules within the volume considered. With $(1/2)mw_1^2$ being the (partial) kinetic energy of a molecule, N_v being the total number of

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molecules within that layer, C_2 being the new norming constant, and the integral of $C_2\exp(-mw_1^2/(2k_BT))dw_1$ (taken from zero to infinity) thus being equal to unity, we arrive at

$$\frac{1}{2}m\overline{w_1^2} = \frac{\int_0^\infty \frac{1}{2}mw_1^2 N_v C_2 e^{-\frac{m}{2kT}w_1^2}dw_1}{\int_0^\infty N_v C_2 e^{-\frac{m}{2kT}w_1^2}dw_1} = \frac{1}{2}kT. \qquad (1d)$$

So far, it appears as if the thesis of a uniform temperature of the gas has been proven instead of being falsified. It is no surprise to realize that Walton,[6] in an attempt to prove the uniformity of temperature within a column of gas, reversed the order of steps, thus starting with Maxwell's distribution and ending with the barometric formula.

However, things look different as soon as we replace the smooth walls of the column by rough ones (right side of Figure 2). Whatever the direction of travel might have been prior to the collision with the rough wall, the direction in which a molecule is reflected shall be completely at random. Of course, downward reflections will then be as frequent as upward reflections. In order to assure that the molecule continues its journey upward, we shall use a little trick: Each molecule shall be identified by a name tag. When the molecule is going upward, the color of its tag shall be green. When it is going downward (after either having reached the top or after having slowed down to a total velocity of zero), the color of its tag shall turn blue. Both bottom and top are thus places to change the color of tags. It is quite obvious that there are equal numbers of green and blue tags in our column (if the situation is that of an equilibrium). Moreover, each molecule shall belong to a certain speed class. A speed class is defined by the initial *total* velocity of a molecule (which it has at the bottom). The limits of each class are thus v_{tot_k} and $v_{\text{tot}_k} + dv_{\text{tot}}$ (with the subscript k ranging from 1 to the total number of speed classes). Each speed class comprises a very large number of individual molecules. This is why there are equal numbers of green and blue tags in each of the many speed classes. So when a molecule with a green tag (which stands for *upward* motion) is reflected *downward* (by the rough wall) it exchanges its tag with a blue-tagged "classmate" (a molecule belonging to the same speed class) that is about to go upward after reflection (the reflection having taken place at the same height above the bottom at which the reflection of the green molecule took place). On the macroscopic level, on which questions about the identity of an individual molecule are of no importance, this trick has no effect. Hence, we are allowed to say that all green-tagged molecules experience upward reflections only, whereas all blue-tagged molecules experience downward reflections only. As a consequence, all molecules whose *total* velocity v_{tot} is equal or greater than $(2gh)^{1/2}$ make it to the top. As a further consequence, every w_1 in our equations (1a) to (1c) would have to be replaced by a v_{tot} (w_{crit} has to be replaced by $v_{\text{tot}_{\text{crit}}}$). As directions of travel within a layer of differential thickness are always equally distributed among the many members of a speed class, the spatial density of molecules in the layer dz is not only proportional to $1/w_1$, but also to $1/v_{\text{tot}}$. Consequently, w_1 would have to be replaced by v_{tot} in (1d), too. One result of our exchange of variables would be the following: The distribution displayed in the third line of (1c) would no longer be Maxwellian. Moreover, (1d), which now gives the *total* average kinetic energy of a molecule, would read

$$\frac{1}{2}m\overline{v_{\text{tot}}^2} = \frac{1}{2}k_bT. \qquad (1e)$$

Equation (1e), however, is wrong in a physical sense, since the average of the total kinetic energy of a molecule is $(3/2)k_BT$. In other words: the thesis of a homogeneous temperature of the heavy gas and a set of well-corroborated physical laws (from which $(3/2)k_BT$ as the average kinetic energy of a molecule is derived) contradict each other. Assuming that those physical laws are valid, the thesis of a homogeneous temperature of the heavy gas has to be discarded.

Which model is closer to reality, that with smooth walls, or that with rough walls? Certainly that using rough walls. The mutual collisions of the real molecules provide an even distribution of losses or gains in kinetic energy among all three components of velocity. The smooth walls lack such a mechanism, which assures that a change in kinetic energy (brought about by an increase in gravity, for instance) is eventually shared by all three components of velocity.

In his attempt to prove the uniformity of temperature, Garrod[1a] (like Walton) did not use a rough wall by which the molecules are deflected. As in Walton's model, there is no contribution of the other two components of kinetic energy to the ascent of a molecule. So it cannot be a surprise that Garrod was able to "prove" the uniformity of temperature.

5. A Second Refutation of the Homogeneous Temperature in Gases Subject to Gravity

Imagine a system of coordinates in which the three axes do not represent spatial directions, but velocity components. A point in that "velocity space" can be ascribed three coordinates indicating its three velocity components in space (in the x-, y-, and z-directions). A certain quantity of gas containing billions and billions of molecules may, at an arbi-

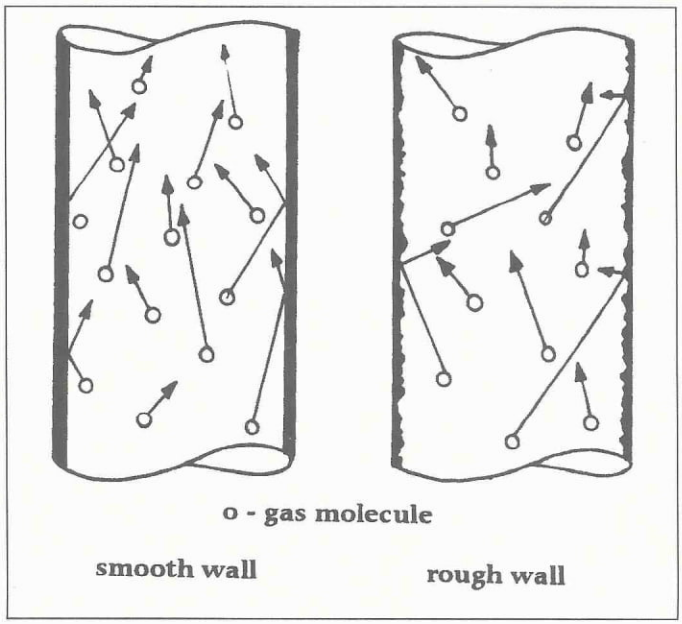

Figure 2. A model gas in two different containers.

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trarily chosen point in time, be represented by means of such a three-dimensional coordinate system (= the so-called velocity space). Each molecule is represented by a point the position of which tells us about the velocity of that individual molecule. According to the Boltzmann distribution (valid for a gas not subject to gravity), the density of points in that velocity space declines when moving away from the origin of coordinates. As a further postulate of the Boltzmann distribution, the rate of decline, however, does not depend on the direction in which we move away from the origin of coordinates, but only on the distance.

Now we replace the many molecules by just one, but watch that single molecule over a certain period of time during which it changes its velocity because of collisions it undergoes with other molecules or with the walls of the container. Each point in the velocity space represents a certain point in time separated from its neighbors in time by a fixed temporal interval *dt*. For instance, ten points at a single spot indicate that the molecule had that velocity at ten points in time, either consecutively or not. Provided that the number of collisions equals the number of molecules in our previous thought experiment, the total number of points and their distribution in the velocity space will not differ from those in the previous case. The situation is analogous to casting dice: no matter if ten thousand dice are cast at the same time, or if one die is cast ten thousand times consecutively, the distribution of results obtained is the same in both cases.

Every once in a while our molecule undergoes a central collision. Because of the principle of conservation of momentum, two competing descriptions of what is going on are equally justified when viewed macroscopically (see Figure 3):

1) each of the two molecule has its path reversed, or
2) the two molecules penetrate each other without disturbing their paths (as waves do), just as if they did not consist of tangible matter.

Now let us agree on the second description every time our molecule has an upward component of velocity (before collision) and collides with a molecule that has an odd number. (Half of the molecules in the gas shall have odd numbers assigned to them, the other half—including the molecule we are considering—have even numbers.) In all other cases of collisions, the usual description shall be kept.

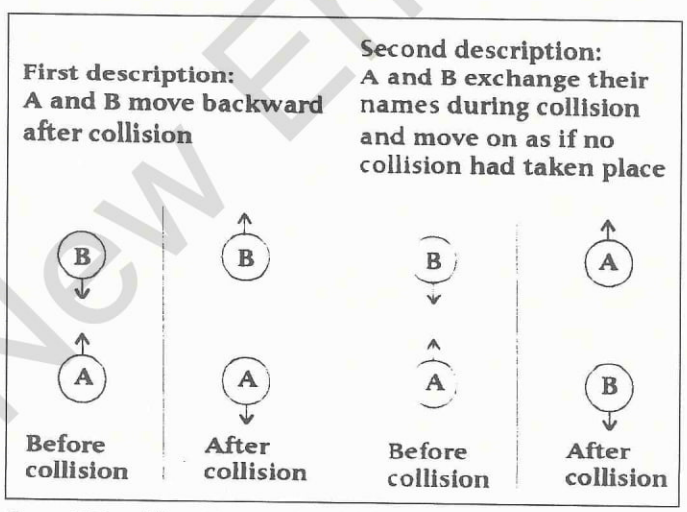

Figure 3. Two different but equally valid descriptions of the same collision.

What are the consequences of our modified view? For our molecule with an even number, the point density in velocity space will not be independent of the direction from the origin. Rather, the sum of the velocity components directed upward of all points will now exceed the sum of the velocity components directed downward. This is why a molecule with an even number moves upward (the so-defined speed of upward motion is not necessarily constant). For the molecules with odd numbers, the situation is just the contrary; therefore those molecules move downward.

As soon as our molecule reaches the top of the container (where it undergoes an elastic reflection), it changes its even number for an odd one and starts its journey downward. Thus, we have a constant upward and a constant downward stream of molecules in the gas in which every molecule participates. The situation is the same as if the two streams of gas were flowing through vertical pipes in thermal contact with each other. At any height, the temperature would be the same for both pipes. A vertical stream of gas, however, exhibits a temperature gradient when the force of gravity is at work. More precisely, such a stream exhibits an adiabatic temperature gradient. It shall be quantified in the following section.

6. The Temperature Gradient of a Stream of Ideal Gases Subject to Gravity

Imagine a long pipeline running over a flat plain (Figure 4). At the edge of the flat plain, the pipeline climbs a cliff. Having overcome that obstacle, the pipeline continues its path over another flat plain. The difference in altitude shall be *h*.

On the lower plain, a quantity *M* of ideal gas is sealed off by two movable pistons in the pipeline. The quantity *M* shall be brought to the upper plain by shifting the pistons. No thermal energy shall be added to the gas from outside, nor shall any thermal energy be taken from the gas.

According to the first law of thermodynamics, the gain in potential energy of the gas *M* (the molecules have been lifted over the vertical distance *h*) must be compensated by the loss in thermal energy *U* of the gas (= kinetic energy of the molecules), and by the amount of net work that is spent on the gas by means of the pistons (if there is such an amount). Net work would be spent on the gas if the product p_1V_1 exceeded the product p_2V_2. The first product describes the work spent on the piston on the lower plain: p_1 denotes the constant pressure in

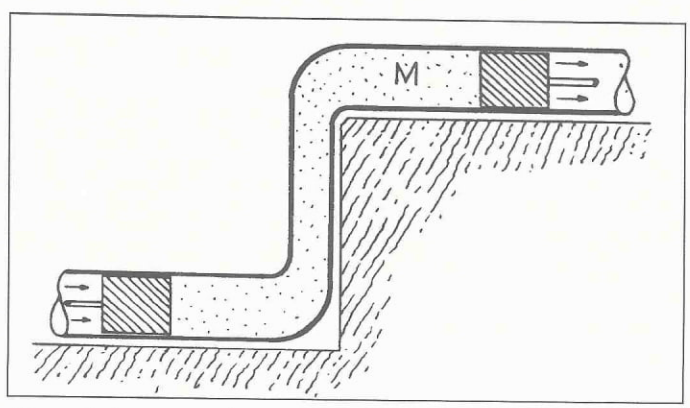

Figure 4. A quantity of gas *M* in a pipe driven by two pistons.

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the lower pipeline; V_1 is the volume of M in the lower pipeline. The second product describes the work done by the piston on the upper plain (when the quantity of gas M is entering the pipeline on the upper plain): V_2 is the volume that M occupies on the upper plain; p_2 is the constant pressure on the upper plain. The amount of gas located in the vertical section of the pipeline shall be negligibly small compared to M.

So we would formulate

$$-(U_2 - U_1) + (p_1V_1 - p_2V_2) = Mgh. \tag{1f}$$

If h becomes differentially small, we can formulate

$$-MC_v dT + (p_1V_1 - p_2V_2) = Mgdh. \tag{2}$$

C_v [J kg^{-1} K^{-1}] represents the specific heat capacity at constant volume, T the temperature, and V the volume of M. Rearranging the equation, we get

$$-dT = \frac{Mgdh - p_1V_1 + p_2V_2}{MC_v}. \tag{3}$$

The term $p_1V_1 + p_2V_2$ can be substituted by $MR(T_2 - T_1)$ due to the equations

$$p_1V_1 = MRT_1 \tag{4}$$

and

$$p_2V_2 = MRT_2. \tag{5}$$

The term R [J kg^{-1} K^{-1}] denotes the gas constant, which, in turn, can be replaced by $C_p - C_v$, with C_p [J kg^{-1} K^{-1}] denoting the specific heat capacity at constant pressure. With the difference in temperature being differentially small only (as h has become differentially small), the term $-p_1V_1 + p_2V_2$ can be replaced by $MdTR$.

Therefore, (3) turns into

$$-dT = \frac{Mgdh + MdTR}{M(C_p - R)}, \tag{6}$$

$$-dT(C_p - R) = gdh + dTR, \tag{7}$$

$$-dTC_p = gdh, \tag{8}$$

$$\frac{dT}{dh} = -\frac{g}{C_p}. \tag{9}$$

As can be taken from textbooks on meteorology, this result is identical to the adiabatic temperature gradient in the atmosphere. (The temperature gradient of the atmosphere is adiabatic if a rising cushion of air in the atmosphere has, at any height, the same temperature as the air surrounding it, without receiving heat or giving out heat from its surroundings.)

7. The Temperature Gradient of Real Gases Subject to Gravity

In order to determine the temperature gradient for real gases, we have to start with

$$-dU + (p_1V_1 - p_2V_2) = Mgdh, \tag{10}$$

which is equivalent to (2). U denotes the internal energy of M. A rearrangement of the equation leads to

$$-(U_2 - U_1) + (p_1V_1 - p_2V_2) = Mgdh \tag{11}$$

or

$$-U_2 - p_2V_2 + U_1 + p_1V_1 = Mgdh \tag{12}$$

or

$$-[(U_2 + p_2V_2) - (U_1 + p_1V_1)] = Mgdh \tag{13}$$

or

$$-dH = Mgdh, \tag{14}$$

with H denoting the enthalpy ($U + pv$) of the gas. Equipped with these data, we can use an enthalpy-entropy chart of the gas we are dealing with, locate the one-dimensional point representing the gas at the base of the column, and move down on the chart (due to the constancy of entropy) over a distance that stands for the difference in enthalpy we are dealing with. The difference in enthalpy, in turn, is a function of h. The second point so marked represents the gas at its state at the top of the column. The temperature, density, and pressure belonging to that second point can be looked up on the chart.

8. A Refutation of Boltzmann's "Proof" of a Uniform Temperature of Gases Subject to Gravity

The contradicting views on the distribution of temperature in such a gas were held most vividly by Loschmidt and Boltzmann. Loschmidt postulated the decline of temperature with height (both for solid substances and gases) and therefore the possibility of a perpetual motion machine of the second kind:

> The result achieved in the foregoing, according to which local differences in temperature can occur and persist in a system of aligned atoms exposed to gravity, is in direct contradiction to a basic theorem of the theory of heat, which claims that no work can be obtained from the active force of a system of bodies being in the state of thermal equilibrium.[7]

As opposed to this, Boltzmann asserts that the gas has a homogeneous temperature. It is worth mentioning that Boltzmann refrains from attacking Loschmidt with the negative argument that the gradation of temperature entailed the possibility of a perpetual motion machine of the second kind.

Boltzmann explicates his view by combining his distribution of velocities (which had been set up for an isothermal gas beyond the reach of gravity) and the formula of the baro-

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metric gradient.[8a] Thus, he obtains the following distribution of velocities:

$$dN = C\exp[-h(u^2+v^2+w^2)-kz]dudvdwdz. \quad (15)$$

The two horizontal components of velocity are represented by u and v; w stands for the vertical component of velocity. The variable z measures the height of a layer on a vertical axis of coordinates; C, h, and k are defined as (unknown) constants. The expression dN denotes that portion of molecules (their total number being N) the velocities of which range from u to $u + du$, from v to $v + dv$, from w to $w + dw$, and the z-coordinates of which range from z to $z + dz$. Boltzmann conceives a gas in which the distribution mentioned above is established at time zero. He asks whether or not the distribution is about to change in the course of time as a result of gravity; in other words, whether or not (15) is still capable of describing the state of the gas after some time has passed. In case the answer is in the positive, he regards his thesis (of a homogeneous temperature of the gas) as being approved. For the sake of simplicity, he assumes (for a while) that no collisions of molecules take place. The only collisions they undergo are the reflections by the vertical walls of the container. Since these reflections do not have any effect on the horizontal components of their velocities (in absolute numbers), it is clear that the number of those molecules the components of which ranged from u to $u + du$ and from v to $v + dv$ at time zero is not affected by gravity and hence remains constant over time.

With regard to that number, he asks whether the fraction of molecules the vertical velocity w of which ranged from w to $w + dw$, and the z-coordinates of which ranged from z to $z + dz$ at time zero, remain in dw- and dz-intervals of the same widths even after the molecules have been subject to gravitation. As the vertical velocities of all the molecules, in a given time, increase (or decrease) by the same amount as a result of gravity, the width of the w-interval, *i.e.* dw, does indeed remain unchanged. Boltzmann's computations, however, lead to the outcome that the width of the z-interval, *i.e.* dz, does not stay constant over time. This is quite evident: the molecules have different velocities ranging within the interval dw at time zero, hence their mutual distance is changing in the course of time.

The widening of the dz-interval does not vanish when it comes to differential values of t. Let us see why: The molecule with the smallest initial value of z and the smallest initial value of w will, after time interval dt has elapsed, find itself at

$$z + \left(w + \frac{1}{2}gdt\right)dt. \quad (16)$$

The molecule with the greatest initial value of z (which is $z + dz_0$) and the greatest initial value of w (which is $w + dw$) will, after time interval t has elapsed, find itself at

$$z + dz_0 + \left(w + dw + \frac{1}{2}gdt\right)dt. \quad (17)$$

Subtracting the first expression from the second one, we arrive at

$$dz_0 + dwdt \quad (18)$$

for the increased width of the z-interval. The initial z-interval would remain unchanged if not only dt, but also dw, approached zero. The error (brought about by considering dz as being constant over time) would then be of second order only. That is, even if those errors were summed up ($\Delta t/dt$) times during an integration, that sum would nevertheless vanish because of being equivalent to

$$dwdt + dwdt + \cdots = dwdt\frac{\Delta t}{dt} = dw\Delta t. \quad (19)$$

The interval dw, however, cannot shrink to zero for statistical reasons—the probability that a single, depicted molecule lies outside an interval dw amounts to

$$P = \frac{\frac{\Delta w}{dw} - 1}{\frac{\Delta w}{dw}} = 1 - \frac{dw}{\Delta w}. \quad (20)$$

The probability of *all* molecules lying outside dw amounts to

$$P = \left(1 - \frac{dw}{\Delta w}\right)^N. \quad (21)$$

With N being finite, Δw not shrinking to zero, and dw shrinking to zero, P approaches the value of 1. In other words, if dw is allowed to shrink toward zero, the chances for an interval dw to host just a single molecule approach zero.

So Boltzmann tries to prove that, despite the change of interval dz in which the molecules can be located, a certain feature linked to the product $dwdz$ stays invariant at least—when drawing a two-dimensional system of coordinates with z and w as the two perpendicular axes, one can recognize that the surface area F in which the molecules described are located is identical in size (not in shape) whatever point in time is depicted. In an effort to take advantage of this constancy, Boltzmann modifies (15) by replacing the product $dwdz$ with the area F formed in the coordinate system (w, z). By means of this artifice, the widths of the intervals remain unchanged.

One has to concede that the assumption of constant widths of intervals and the antithetical supposition of changing widths are equally justified, depending on whether or not the product $dwdz$ is replaced by the area F in (15). With dw staying invariant and dz undergoing a change, the product $dwdz$ does not remain constant in a strict sense. Boltzmann does not provide arguments for the assumption that $dwdz$ *must* be replaced. For this reason alone, his "proof" is not convincing.

Boltzmann continues his train of thought as follows: As he has proved the differentials $dudvdF$ to be constant over time despite the influence of gravity, the remaining thing to do is to show that the term

$$C\exp[-h(u^2+v^2+w^2)-kz] \quad (22)$$

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equals the term

$$C\exp\left\{-h[u^2+v^2+(w+gt)^2]-k\left(z-wt-\frac{gt^2}{2}\right)\right\} \quad (23)$$

(the former term describes the state of the gas at time zero; the latter term describes the state of the gas at a later point in time, after z and w have changed as a result of gravitation). If this task could be coped with, Boltzmann would have proved that (15) is able to describe the state of the gas even under the influence of gravity.

Boltzmann shows that (22) and (23) are equivalent as soon as the constant k is substituted by $2gh$. However, he has to be criticized for not having proved that his substitution $k = 2gh$, aside from being successful in a mathematical sense, is consistent with other laws of physics. In other words, if $k = 2gh$ contradicted other laws of physics, that substitution could not be useful in physics.

Whether or not the equation $k = 2gh$ is empirically correct can only be decided after the constants C, h, and k appearing in (15) are determined (without using the equation $k = 2gh$). This is what we will do in the following.

Boltzmann's first starting point is his formula of the distribution of velocities, which is

$$dN(u,v,w) = N\left(\frac{m_t}{2\pi k_B T}\right)^{3/2}\exp\left[-\frac{m_t}{2k_B T}(u^2+v^2+w^2)\right]dudvdw, \quad (24)$$

with k_B denoting the Boltzmann constant, and m_t denoting the mass of a molecule. Because of $(1/2)m_t\,\overline{v^2_{tot}} = (3/2)k_B T$, (24) can be turned into

$$(dN)_1 = N\left(\frac{3}{2\pi\overline{v^2_{tot}}}\right)^{3/2}\exp\left(-\frac{3}{2\overline{v^2_{tot}}}(u^2+v^2+w^2)\right)dudvdw, \quad (25)$$

where $\overline{v^2_{tot}}$ denotes the mean square of the molecules' total velocities.

Now we turn to the second starting point of Boltzmann's formula. For an isothermal gas subject to gravity, the pressure p is a function of the height z above the ground:

$$p = p_0 e^{-\frac{q_0}{p_0}gz}. \quad (26)$$

The term q_0 denotes the density of the gas at the base, p_0 denotes the pressure of the gas at the base, and g denotes the gravitational acceleration. For a gas of constant temperature, the number of molecules is proportional to the pressure of the gas provided that the volume of the gas, that is, the height dz of the stratum considered, remains constant. On the other hand, the number of molecules is proportional to the volume of the gas, that is, to the height dz of the stratum multiplied by the area of the base of the column, provided that the pressure remains constant. As a consequence, the number of molecules is proportional to the product of pressure and volume. Hence, for a gas of constant temperature, we have

$$(dN)_2 = apAdz, \quad (27)$$

with a denoting the (temperature-dependent) factor of proportionality. The term A denotes the area of the base of the column. When, in (27), p is substituted by the right side of (26), and if, in addition, both sides are multiplied by $1/N$, we arrive at

$$\frac{(dN)_2}{N} = \frac{1}{N}ap_0 e^{-\frac{q_0}{p_0}gz}Adz. \quad (28)$$

Searching for the number of molecules the velocities of which range within u and $u + du$, v and $v + dv$, w and $w + dw$, and the z-coordinates of which range between z and $z + dz$, the right sides of the two equations (25) and (28) must be multiplied by each other. So we get

$$dN = ap_0 A\left(\frac{3}{2\pi\overline{v^2_{tot}}}\right)^{3/2} \times \exp\left(-\frac{3}{2\overline{v^2_{tot}}}(u^2+v^2+w^2)-\frac{q_0}{p_0}gz\right)dudvdwdz. \quad (29)$$

As a consequence, the constants C, h, and k can be determined as follows

$$C = ap_0 A\left(\frac{3}{2\pi\overline{v^2_{tot}}}\right)^{3/2}, \quad (30)$$

$$h = \frac{3}{2\overline{v^2_{tot}}}, \quad (31)$$

$$k = \frac{q_0}{p_0}g. \quad (32)$$

The constant k must not be confused with the general Boltzmann constant k_B or with the constant k appearing in Poisson's equation. We realize that C and h contain $\overline{v^2_{tot}}$ as a factor, which is an expression of the temperature of the gas. Moreover, C contains T explicitly, since the norming constant of the barometric formula (that is, the term a) depends on T.

We are now able to decide whether or not Boltzmann's substitution $k = 2gh$ is empirically justified. When, in $k = 2gh$, the terms k and h are substituted according to (31) and (32), we get

$$k = 2gh \Leftrightarrow \frac{q_0}{p_0}g = 2g\frac{3}{2\overline{v^2_{tot}}}. \quad (33)$$

In the following, the density q_0 is expressed as M/V_0; V_0 is the specific volume of 1 mol of the gas at the bottom, M denotes the mass (in kilograms) of 1 mol. N_L is Loschmidt's number, m_t [kg] denotes the mass of a single molecule, R is the constant, T the temperature, and k_B is Boltzmann's gen-

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eral constant. Because $(1/2)m_t \overline{v^2_{tot}} = (3/2)kT$, the term $\overline{v^2_{tot}}$ can be expressed as $3kT/m_t$. So (33) turns into

$$\frac{M}{p_0 V_0} = \frac{m_t}{k_B T} \tag{34}$$

or

$$p_0 V_0 = \frac{M k_B T}{m_t} = N_L k_B T = RT \tag{35}$$

(dimension of p_0V_0 = J/mol ; dimension of $(Mk_BT)/m_t$ = [(kg/mol)(J/K)K]/kg = J/mol).

Thus, when reversing the order of equations, Boltzmann's substitution $k = 2gh$ can be derived from the basic equation of the ideal gas.

Though the outcome of our calculations appears to approve Boltzmann's reasoning, an evident weakness in his reasoning is revealed when we take a look at the constants h and C. Both are determined by the average square of the molecules' total velocity v_{tot}, that is, by the average kinetic energy of the whole gas. That square of velocity, however, is affected by the change of the velocity w of the molecules considered, which, in turn, is a result of gravity. Boltzmann fails to prove that a change in the average square of the molecules' velocities (caused by the change in vertical velocity of the molecules considered) is avoided by the compensating behavior of other groups of molecules. The only "candidates" that appear to be at hand for such a compensation are the molecules the velocities of which range from u to $u + du$, and from v to $v + dv$, and from $-w$ to $-w - dw$ (ascending molecules). Though, in a given interval dt, their vertical velocity is reduced by the same amount by which the vertical velocity of the molecules considered by Boltzmann (descending molecules) is increased, the loss in kinetic energy of the ascending group, that is, $(1/2)m[w_0^2 - (w_0 - \Delta w)^2]$ for an individual molecule in the ascending group, falls short of the increase in kinetic energy of the descending group, that is $(1/2)m[(w_0 + \Delta w)^2 - w_0^2]$ for an individual molecule in the descending group. Hence, Boltzmann's reasoning is incomplete. He defines C and h as constants though they could be variables. The incompleteness vanishes only when the gravity g approaches zero, that is, when $\overline{v^2_{tot}}$ remains almost invariant.

Loschmidt summarized his own critique on Boltzmann's reflections in the following way:

> First. The results can, because of their starting point, only claim an approximate validity for the real gases, and thus have to be considered worthless for the foundation of strictly valid statements in the mechanical theory of heat. Second. The equality of temperature in all strata of a mass of gas is by no means warranted by the formula found, since for such a warranty it is, in addition, required to assume that the molecules have identical limits of the components of velocity throughout the whole mass of gas. Such an assumption, however, is not admissible with regard to systems of few molecules, and is not proved with regard to those of many ones.[8b,9]

9. Boltzmann's Second Attempt

Some twenty years after his discussion with Loschmidt, Boltzmann revised his argument in his *Lectures on Gas Theory* (1896-1898).[10,11] Seemingly, he realized that his first proof was not valid, as he openly admitted that the alleged constants might be variables,[10] just as we did in the previous section. Of course, he tries to give a new proof of the thesis that these constants do not depend on height. Boltzmann's second attempt to prove the uniformity of temperature shall be discussed in the following.

In Chapter 2 of *Lectures on Gas Theory*, he writes (some Greek letters have been replaced by Latin ones):[11]

> We fix our attention on the parallelepiped representing all space points whose coordinates lie between
>
> $$x \text{ and } x + dx,\ y \text{ and } y + dy,\ z \text{ and } z + dz. \tag{97}$$
>
> . . .The velocity of each m-molecule that finds itself at time t in this parallelepiped shall be represented by a line starting at the origin, and the other end point C of this line will again be called the velocity point of the molecule. Its rectangular coordinates are equal to the components u, v, w of the velocity of the molecule in those coordinate directions.
>
> We now construct a second rectangular parallelepiped, which includes all points whose coordinates lie between the limits
>
> $$u \text{ and } u + du,\ v \text{ and } v + dv,\ w \text{ and } w + dw. \tag{98}$$
>
> . . .The m-molecules that are in [the first parallelepiped] $dxdydz$ at time t and whose velocity points lie in [the second parallelepiped] $dudvdw$ at the same time will again be called the specified molecules, or the dn molecules. Their number is clearly proportional to the product $dxdydzdudvdw$. Then all volume elements immediately adjacent to $dxdydz$ find themselves subject to similar conditions, so that in a parallelepiped twice as large there will be twice as many molecules. We can therefore set this number equal to
>
> $$n = f(x, y, z, u, v, w, t)dxdydzdudvdw. \tag{99}$$

Now Boltzmann considers the molecules that are located to the left of the parallelepiped $dxdxdz$ in real space. Provided that they have an exact velocity u (in fact their velocity ranges from u to $u + du$) all molecules within a distance of udt will manage to fly through the left face of our parallelepiped within that temporal interval dt. Their number equals

$$f(x, y, z, u, v, w, t)udtdydzdudvdw. \tag{36}$$

Equation (36) is arrived at by replacing the term dx appearing in Boltzmann's Equation (99) with udt. The function f is an expression of the particle density at the depicted spot in the combined, six-dimensional space, or, in other words, an expression of the density of particles with a certain velocity at the depicted spot in the three-dimensional real space. Of

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course, (36) is correct only as long as we neglect v and w. These components may cause the molecule (which has left the parallelepiped) to miss the parallelepiped during time dt.

Similarly, the number of molecules leaving the parallelepiped $dxdydz$ through its right face will be

$$f(x+dx, y, z, u, v, w, t)udtdydzdudvdw. \tag{37}$$

The difference between the two expressions amounts to

$$\frac{\partial f}{\partial x} dxudtdydzdudvdw, \tag{38}$$

with $(\partial f/\partial x)dx$ denoting the partial differential of f.

By similar arguments for the four sides of the parallelepiped one finds that during time dt,

$$-\left(u\frac{\partial f}{\partial x} + v\frac{\partial f}{\partial y} + w\frac{\partial f}{\partial z}\right) dxdydzdudvdwdt \tag{39}$$

more molecules enter the parallelepiped $dxdydz$ than leave it as a consequence of their velocities.

So far, the change in speed of the molecules during dt has not been taken into account. Boltzmann tries to do this by showing (as a first step) that in velocity space, the points representing molecules move with constant speed when subject to acceleration, and are at rest when not subject to acceleration. So he employs completely similar arguments (bringing about similar inaccuracies) with respect to the motion of velocity points (through the parallelepiped $dudvdw$) as he previously did for the motion of the molecules themselves in real space (through $dxdydz$). In the former case, the velocity of a molecule was assumed to be constant over the path of the molecules during dt (the function f was differentiated by x only), now the spatial density (for any given class of molecules having speeds between u and $u + du$) is assumed to be constant over the path of the molecules during dt (the function f is differentiated by u only). So Boltzmann finds that in all,

$$-\left(X\frac{\partial f}{\partial u} + Y\frac{\partial f}{\partial v} + Z\frac{\partial f}{\partial w}\right) dxdydzdudvdwdt \tag{40}$$

more velocity points enter $dudvdw$ than leave it as a consequence of an acceleration the molecules are subject to. X, Y, and Z are the components of that acceleration.

As a next step, Boltzmann argues that for a system to be in an equilibrium, the sum of both expressions has to be zero, since the number of molecules in the six-dimensional parallelepiped has to be constant over time. But admitted by Boltzmann himself, his expressions contain an inaccuracy which has already been mentioned above (velocity and spatial density are considered constant in certain circumstances though they may vary). The extent of that inaccuracy shall be demonstrated in the following: Imagine a box having a hole in its top and in its bottom. Particles of different speed classes are dropped from above (in constant temporal intervals), entering the box through the hole in the top and leaving it through the hole in the bottom. All molecules share the same direction of motion (+z). In other words, u and v are zero all the time. Though the *temporal* gap between those molecules that have the same speed stays constant (when passing through the hole in the bottom of the box), their mutual *spatial* distance increases while they are falling and gathering speed. With the spatial particle density thus decreasing toward the bottom of the box (defined as the positive direction of z) for a given speed, $\partial f/\partial z$ is different from zero (negative) for a given velocity. Boltzmann's formula (39), which (because of the fact that the particle density does not depend on x, y, u, or v) reduces to

$$-w\frac{\partial f}{\partial z} dzdwdt, \tag{41}$$

would thus yield a net increase in the number of molecules inside the box for all velocities (in contrast with reality).

Let us see whether or not the inaccuracy is of second order only. Then it will disappear after an integration. An integration over w (zero to infinity) would lead to the expression

$$a(z)dzdt. \tag{42}$$

To elucidate: $\partial f/\partial z$ may depend on w and on z. This is why an integration over w results in a function of z. The value of that function $a(z)$ can easily be determined for the top of the box. At this particular location, the term $-w\partial f/\partial z$ is positive for all positive values of w (since the density of particles is decreasing with z whatever group of molecules is considered). Hence $a(z)$, which is the sum of all these numbers, has to be positive for this particular value of z. The same applies to all locations z between the top and the bottom of the box. So an integration over z leads to

$$Cdt, \tag{43}$$

with the constant C being greater than zero.

After a final integration over t, we would still have a positive number different from zero. Thus, the inaccuracy is of first order.

Let us now turn to the second term, which is supposed to yield the number of molecules entering or leaving $dudvdw$ (and hence the six-dimensional parallelepiped) as a consequence of acceleration. Again, there is an inaccuracy contained in that expression (admitted by Boltzmann himself), and we will see whether or not it is of second order only (or whether it is even capable of compensating the inaccuracy of the first expression). We will therefore return to our box. Boltzmann's expression (40) reduces to

$$-Z\frac{\partial f}{\partial w} dzdwdt. \tag{44}$$

An integration of (44) over w would yield

$$b(z)dzdt, \tag{45}$$

since $\partial f/\partial w$ may depend on z and on w. As we can arrange the distribution function f according to our wishes, we determine that there are fewer molecules with higher

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speeds than with lower speeds; hence $\partial f/\partial w$ is negative for all positive values of w no matter which spot within the box is considered. Consequently, at a depicted location z between the top and the bottom, the expression $-Z\partial f/\partial w$ is a positive number for any positive velocity w. Then $b(z)$ must, at this location z, be a positive number, since it is the sum of all these previous numbers. The same applies to all locations z between the bottom and the top. This is why an integration over z yields

$$Kdt, \tag{46}$$

with K representing a positive constant. A final integration over t would again lead to a positive numerical value.

As a result, the sum of Boltzmann's differential expressions yield a result different from zero though the system we constructed *is* in a state of equilibrium. Therefore, the method he suggests for describing a state of equilibrium is not valid. This is just one reason why his second attempt, which is based on that method, fails. We thus do not have to follow Boltzmann's train of thought any further.

10. May Even a Nonequilibrium Gradation of Temperature Enable the Operation of a Machine Similar to Maxwell's?

We shall try to demonstrate that a perpetual motion machine of the second kind could be run even if the stratification of temperature in a gas subject to gravity did not represent a state of equilibrium, but only a temporary effect. For this purpose, we will consider a column of quadratic square section filled with gas (Figure 5). Initially, this column lies horizontally on the ground, but is then brought into a vertical position with its bottom end functioning as a footpoint. During this process, the lower part of the column is kept at constant and uniform temperature (that of the ambient), while the upper part is kept in an adiabatic state. Having reached its vertical position, the column is brought back into its horizontal position on the ground; during this process, both the lower and the upper parts of the column are kept at constant and uniform temperature (that of the ambient).

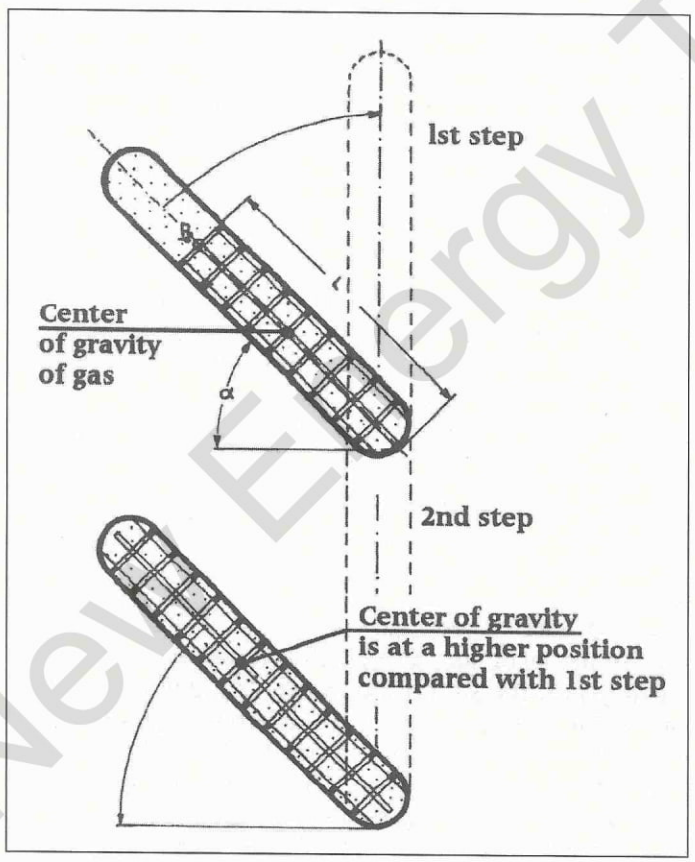

Figure 5. A closed tube filled with gas being erected as the first step, and being lowered thereafter as the second step of a complete cycle.

It shall be proved that the center of gravity of the column is more distant from the center of rotation (= the footpoint) when the column has a uniform temperature, and is closer to the center of rotation when the upper part of the column is kept in an adiabatic state. Consequently, the work gained when lowering the cylinder, that is, the torque multiplied by the differential angle of rotation (integrated over 90°), would exceed the work spent on erecting the cylinder.

In order to prove this, we will have to find out which points of the column undergo a decrease in pressure while the column is being erected at constant temperature (that of the ambient). We start with the barometric formula. We suppose the pressure at the very top to be vanishingly small after the position of the long column is no longer horizontal (the column is very long compared to its width, and gravity is very high). Then, if the column is *fully* erected, the pressure at the bottom equals Mg/A, with A denoting the surface area of the base. The pressure (as a function of z) would then be

$$p = p_0 e^{-\frac{g}{RT}z} = \frac{Mg}{A} e^{-\frac{g}{RT}z}. \tag{47}$$

Because the surface area is quadratic with d denoting the length of a side, A can be replaced by d^2. What about the barometric formula if the column is not *fully* erected? Figure 5 reveals

$$p = \frac{Mg\sin\alpha}{d^2} e^{-\frac{g}{RT}z}. \tag{48}$$

In order to substitute the vertically measured height z of a point, we write

$$\sin\alpha = \frac{z}{L}, \tag{49}$$

with L denoting the distance of a point in the column from the bottom of the column. This again modifies the barometric formula:

$$p = \frac{Mg\sin\alpha}{d^2} e^{-\frac{gL}{RT}\sin\alpha}. \tag{50}$$

For an easier differentiation, the parameter t is introduced:

$$\begin{aligned} -\frac{gL}{RT}\sin\alpha &= t, \\ \frac{dt}{d\alpha} &= -\frac{gL}{RT}\cos\alpha, \\ \sin\alpha &= -t\frac{RT}{gL}. \end{aligned} \tag{51}$$

Thus the barometric formula turns into

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$$p = -\frac{MRT}{d^2L} te^t. \tag{52}$$

Differentiation and resubstitution of the parameter t lead to

$$\begin{aligned}
\frac{dp}{dt} &= -\frac{MRT}{d^2L} te^t - \frac{MRT}{d^2L} e^t = -\frac{MRT}{d^2L} e^t (t+1), \\
\frac{dp}{d\alpha} &= \frac{dp}{dt}\frac{dt}{d\alpha} \\
&= \frac{MRT}{d^2L} e^t (t+1) \frac{gL}{RT} \cos\alpha \\
&= \frac{MG}{d^2} e^{-\frac{gL}{RT}\sin\alpha} \left(1 - \frac{gL}{RT}\sin\alpha\right) \cos\alpha.
\end{aligned} \tag{53}$$

If $dp/d\alpha < 0$ for a given inclination of the column, our arbitrarily chosen point in the column, whose fixed distance from the bottom of the column (not from the ground) has been called L, undergoes a decrease in pressure while the angle of inclination is widened. For $dp/d\alpha$ to be smaller than zero, the bracket in the last line of (53) has to be smaller than zero. We would then have

$$\begin{aligned}
&1 - \frac{gL}{RT}\sin\alpha < 0, \\
&\frac{gL}{RT}\sin\alpha > 1, \\
&L > \frac{RT}{g\sin\alpha}.
\end{aligned} \tag{54}$$

From the last equation one can infer that the point L (above which pressure is declining) moves downward when the inclination of the column is increased. It reaches its lowest position when the column is fully erected.

Let us now reformulate (and modify) our thought experiment: The column, which, initially, found itself in a horizontal position, is erected at uniform and constant temperature until the pressure of the gas at the top of the column is vanishingly small. The angle of inclination is still below 90°. Then we continue erecting the column, but now it is kept adiabatic in the upper section above $L = RT/(g\sin\alpha)$, while the lower section is still kept isothermal at ambient temperature (for instance, copper ribs for easy heat conduction, which have been evenly distributed within the column, are now removed from the upper region). The pressure at any height *below* that point will be the same function of the inclination of the column, no matter whether the region *above* that point is still at uniform temperature—at a given angle of inclination, the pressure at the very bottom of the column is only a function of the total mass of the gas (the pressure at the very top was supposed to be vanishingly low); with the pressure at the very bottom being identical in both cases, the pressure at any height within the *lower* section, too, has to be the same in the two compared cases.

This, however, implies that the portion of the total mass of gas M that finds itself *above* that point L is, at any given angle of the increasing inclination, the same in the two compared cases. In case of a *uniform* temperature of the whole column, the pressure at all heights above that point (and hence the total quantity of gas above that point) decreases when the inclination increases. With the total quantity of gas above that said point also decreasing in case of an *adiabatic* change of states, a gas sample in that region will undergo an adiabatic expansion and will begin to cool down while the inclination is increased.

As a consequence, at any angle of inclination, the vertical height of any differential and horizontal layer of gas in the upper section of the column (the variable thickness of the layers is chosen in such a way that each layer contains the same mass m) is smaller than it would be if the temperature were completely uniform (and thereby higher). As a further consequence, the center of gravity of the upper section (and hence also the center of gravity of the complete column) is higher above ground if the column is of *uniform* temperature than it is if the upper section is *cooler* than the rest. Then, of course, the lever arm is longer (at any angle of inclination).

Now it can be realized that the work spent on bringing the column into a vertical position is lower in amount than the work gained when re-lowering the column into its original position at uniform and constant temperature at all heights (that of the ambient). The difference between the two amounts of work involved is equal to the net heat that has flown into the gas from the ambient.

11. A Late Completion of Boltzmann's Homage Paid to Loschmidt

After Josef Loschmidt died in 1895, Boltzmann held a memorial speech addressed to the Chemical-Physical Society of Vienna (October 29, 1895). On this occasion, he rated the computation of the number of molecules contained in a unit volume to be Loschmidt's greatest discovery.[12] Such a rating must be contradicted. A discovery at least equivalent to the one mentioned by Boltzmann is the compatibility of the Second Law of thermodynamics and the perpetual motion machine of the second kind. If Loschmidt's discovery of that compatibility had been widely accepted in those days, the evolution of energy technology might have been a different one. Unfortunately, Loschmidt's arguments in favor of the stratification of temperature in a gas subject to gravity do not provide a strict proof. With a strict proof at hand, he could have spread his thesis with a greater psychological effect.

Furthermore, Loschmidt pointed out that the Second Law could be derived from the principle of least action. To put it differently, he replaced the original foundation of the Second Law (that is, the axiom of the impossibility of a perpetual motion machine of the second kind) with a different one. In doing so, he referred to Boltzmann, who had already displayed such foundation in his article "Über die mechanische Bedeutung des 2. Hauptsatzes der Wärmetheorie." It can be left undecided whether or not the derivation of the Second Law from the principle of least action is strictly convincing. In a recent article, G. Bierhalter, who has published several articles on the history of the Second Law, doubted the strictness of such reasoning.[13] In any case, the Second Law and a perpetual motion machine of the second kind are compatible, as soon as we no longer define the Second Law as has been usual. In that common form, the Second Law asserts that for a quantity of thermal energy to pass from one body to another, the temperature of the receiving body must be lower than that

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of the donating body. Rather, one should formulate (as already proposed above) the Second Law as the assertion that thermal energy does not pass from one body to another if such a passage would destroy a state of equilibrium. A state of equilibrium, in turn, is a state in which the net flow of thermal energy has become zero. To put it differently, if the flow of thermal energy between two bodies has come to a standstill, that flow will not start again by itself. In most cases, the two bodies will then have the same temperature; in some cases, however, the temperatures of the two bodies will be different from each other.

Finally, it should be mentioned that Loschmidt's temperature gradient is inaccurate insofar as he (indirectly) divides the difference in potential energy by the specific heat capacity *Cv*, and not by *Cp*.[14] Hence, his temperature gradient is too steep. In other words, the mean energy of the molecules, that is, the sum of their mean kinetic energy and their potential energy, is not (as Loschmidt assumed) the same at all points of the gas. Rather, it increases with height.

Loschmidt had the following vision for the future:

> Thereby the terroristic nimbus of the Second Law is destroyed, a nimbus which makes that Second Law appear as the annihilating principle of all life in the universe, and at the same time we are confronted with the comforting perspective that, as far as the conversion of heat into work is concerned, mankind will not solely be dependent on the intervention of coal or of the sun, but will have available an inexhaustible resource of convertible heat at all times.[15]

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Perpetual Motion in the 21st Century:

Tethered-Solute Osmosis Membranes and Other Concepts for Demonstrating Second Law Violation

Kevin Varner*

I will begin my presentation with a quote from an article that appeared in the April 2000 issue of *Physics Today*.[1] This quote summarizes the attitude of modern science concerning the total inviolability of the Second Law: "No exception to the Second Law of Thermodynamics has ever been found—not even a tiny one."

No matter how high and mighty, every law of physics must "earn its keep." In the context of recent efforts concerned with unsuccessful synthesis of "molecular ratchets,"[2,3] A.P. Davis gives (in a review of such devices[4]) the following elaboration:

> To challenge the Second Law may be seen as scientific heresy. . .However, as scientists we should take the view that *nothing is sacred* [emphasis added], that experimental results outweigh all theoretical considerations, and that it is quite appropriate to revisit old questions as new techniques become available.

Later in this presentation I will revisit issues connected with molecular ratchets. At this point, I feel it is best to provide some background knowledge for novice individuals concerning subjects such as Brownian motion, kinetic theory, and the heat content of matter. This brief discussion will provide the reader with an understanding concerning the energy production implications for a mechanism capable of demonstrating Second Law violation.

Modern science resolutely maintains that always and forever, as long as eternity rolls, there will never, ever be a way to harness random molecular motion. To do this would violate the Second Law. We know from the most elementary texts on the kinetic theory of matter that such motion explains such things as gas pressure (see Figure 1).

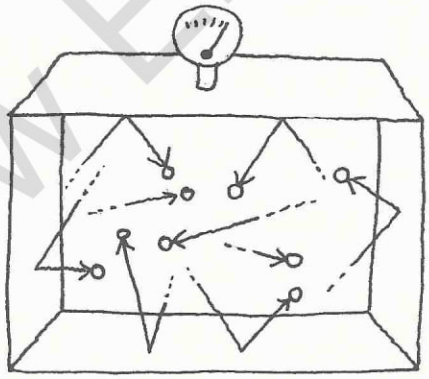

Fig. 1

The following poem provides a capsule refresher course on the kinetic theory of matter:

> Nature, it seems is the popular name
> for milliards and milliards and milliards
> of particles playing their infinite game
> of billiards and billiards and billiards.
>
> —from "Atomyriades" by Piet Hein

Information on the related topic of Brownian motion can be found in Lavenda.[5]

The magnitude of thermal energy (random molecular motion) latent in matter has been known since the time of J.P. Joule. A quote from a 1979 biography of Joule[6] supplies illumination:

> The quantity of heat capable of increasing the temperature of a pound of water by one degree of Fahrenheit's scale is equal to *and may be converted into* [emphasis added] a mechanical force capable of raising 838 lb to a perpendicular height of one foot.

Joule arrived at this statement regarding the mechanical equivalent of heat in the early 1840s. More refined experiments by Joule gave mechanical equivalent of heat values close to the currently accepted value: 1 Btu = 778.1693 ft-lbs.

From page 96 of the Joule biography we learn more:

> On the basis of his reasoning about the zero of temperature, Joule concluded that, at normal temperatures, a pound of matter possessed an extraordinary amount of vis viva (heat). A single pound of water at 60°F must possess 480 + 28 = 508 of heat; in other words, it must possess a vis viva equal to that acquired by a weight of 415,036 lb after falling through a perpendicular height of one foot.

Further elaboration from a different perspective on the kinetic-heat capacity of matter can be found in a 1916 book by Jean Perrin:[7]

> The work done by the stoppage, at this temperature [0°C] of all the molecules contained in 32 grams of oxygen or 2 grams of hydrogen would be sufficient to raise 350 kilograms through one meter; this shows what a reserve of energy lies in molecular motion. . . Again, at the temperature of melting ice, the kinetic energy for [32 grams of] oxygen is the same as if, supposing that all the molecules were stopped, the mass considered had as a whole the velocity of 460 meters per second. . .This is not much less than the speed of a rifle bullet.

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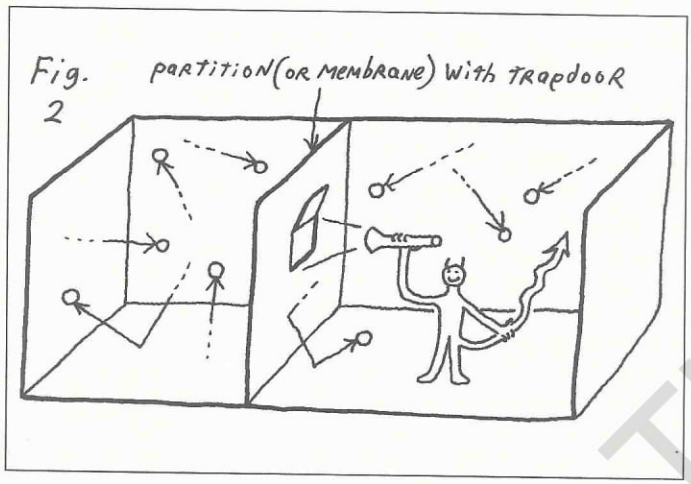
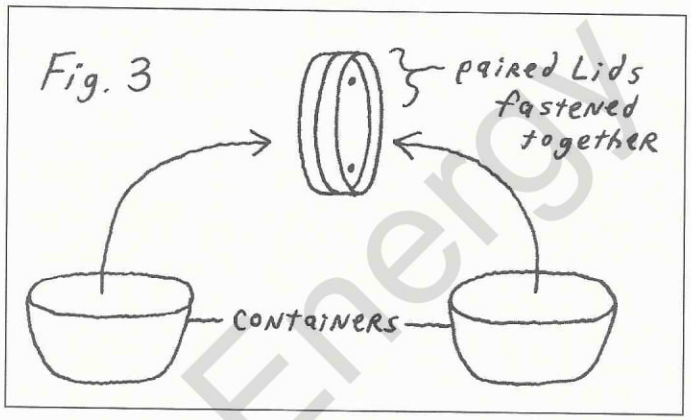
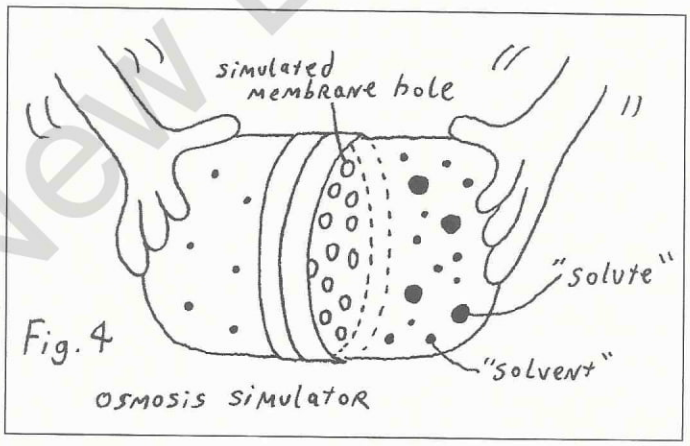
What an incentive we now have to propose experiments leading to the downfall of the Second Law!

In their obsession with maintaining the "Second Law God" on His pedestal, the scientific world has decided that the tenets of something called "information theory" would be rattled to destruction if an anti-Second Law machine was somehow fabricated. A 1990 list of citations that explain this viewpoint can be found in Leff and Rex.[8] This seems to be the "ultimate weapon" defense. Without providing any mathematical jargon, the idea is summarized/diagrammed below in connection with a little fella the physics professors like to call "Maxwell's Demon."

In reference to Figure 2 (yeah right, the guy holding his tail is the Demon), the randomly-flying gas molecules *cannot* accumulate on one side of the partitioned box by knocking past the trapdoor hole all by themselves. According to modern physics, some type of energy input (symbolized by the flashlight held by the Demon) is needed to *inform* the Demon when a specific molecule has the right trajectory to pass through the door. It is supposed to be the case that the energy needed to produce the information required by the Demon so he can open the trapdoor at just the right moment is greater than the energy acquired (pressure increase) provided by the trapped molecule. You got all that?







In the next several paragraphs, I will supply a *long overdue* critique of the Demon as defined above. This critique will conclude with a proposal for a *specific experiment* designed to confirm my anti-Second Law attitude. The experiment will demonstrate what amounts to a new form of osmosis. To understand such an experiment, it seems best to lay a foundation upon the best thinking with regard to conventional osmosis.

Some of the "best thinking" available was provided in a series of five papers that appeared in 1979 in the *American Journal of Physiology*. The introduction to this forum of papers[9] contains a rather startling (to my mind anyway!) admission:

> This Forum on Osmosis [consisting of five invited paper]. . .is intended to provide a comprehensive treatment of osmotic phenomena that can serve as the fundamental source for biologists who are interested in transport processes. I am not aware of a more complete treatment given to this project anywhere else. Many readers will find the issues difficult, or remote, and no wonder. What is under discussion is the microscopic deployment of physical forces that create the macrophenomenon of osmosis, *and this issue has not previously been settled clearly* [emphasis added], either in physics, or in biology.

So in other words, the "Big Brains" in science are not sure what drives osmosis!

By way of developing my argument favoring workability of anti-Second Law "new osmosis," I intend to provide an extensive quote from one of the papers in the above forum. Before I do this, I *insist* that the novice readers set up a macroscopic simulator for osmosis. The simulator is easy to make. It provides a *very accessible* method to demonstrate what really drives osmotic fluid transfer.

The idea behind the simulator is the same as that laid out in another macro-level osmosis demonstrator in which a laboratory beaker was divided by a stiff wire mesh with beans on one side and oats on the other. This alternative design appeared in a peer-reviewed journal in 1999.[10]

My simulator requires a pair of equal-sized Tupperware (or equivalent snap-lid) containers. You must first join together the lids face-to-face, as shown in Figure 3.

After they are joined, open up holes through the paired lids that are just large enough to allow passage of simulated *solvent* molecules but are too small to allow passage of simulated *solute* molecules. A ready source of solvent simulants might be 1/4" steel nuts. The solute simulants could be any particles too big to pass through the holes in the paired lids.

The next step is to put *equal numbers* of simulated solvent particles in each container. In *only one container* do we place the simulated solute particles.

After assembly of the simulator, we can *manually shake it*! (See Figure 4.)

Let the record show here that it is fully accepted practice (as reported in the scientific literature) to use high-speed

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reciprocating or vibrating chambers filled with macro-sized test particles (ball bearings, marbles, whatever) to accurately simulate the behavior of randomly moving molecules *millions of times smaller* than the test particles. As proof of this, we may consider the various chaotic motion generators reported in Sutton.[11] Macro-level chaotic motion has been used to accurately simulate the instantaneous velocity distributions of molecules.[12] Of added interest is Evesque.[13]

We can see that after dismantling the apparatus after a shaking session, the chamber-container with the large non-permeable particles (simulated solutes) will experience a *net migration* of small, permeable particles (simulated solvent) from the chamber-container with no large ones.

And now we come to a Teachable Moment.

Those who have a problem with the Figure 4 osmosis simulator must answer the following question: If the device was progressively scaled down in size, at what dimensional level will it stop working? Do you suppose it will cease to function if the simulant particles averaged "pollen size"? How about if we reduced its size some more and used virus particles as simulated solvent/solute molecules?

I think the inference is unavoidable that we have indeed arrived at a perfectly valid way to macroscopically demonstrate osmotic solvent migration. And now having provided mechanistic insight into osmotic flow, we are ready to consider the promised quote from one of the Forum on Osmosis papers:[14]

> On introducing a crystal of an impermeant solute [to the Figure 5 osmometer device] it is observed that only as the crystal settles on the membrane and dissolves is a drop in pressure in the solvent phase (movement of water into the solution phase) detected. . .A similar experiment could be done by injecting a concentrated solution at the membrane interface and then elsewhere in the fluid volume. This observation is conclusive proof that the presence of the impermeant solute at the membrane interface is the crucial condition for osmotic flow.

It has been suggested that solute concentration differences be used to generate commercial power in osmotic-type power plants.[15] The theory is that you could put salty ocean water on one side of a membrane and fresh water from a river or lake on the other side. The pressure difference could drive a generator. A quote from the paper of note provides a different perspective on the earlier assertion of Yates[9] that ". . .the microscopic deployment of physical forces that create . . .osmosis. . .has not been settled clearly":

> As far as we know, no analysis has been published of the scientific basis of these devices [osmotic power plants] or of their prospects as engineering devices.

I would now like to assert here that it will not be necessary to use salt water and fresh water on different sides of a membrane to create an osmotic power plant. If we use "new osmosis," we *no longer need any freely-diffusing solute.*

I propose that all an experimenter has to do is to *tether a monolayer* of impermeable solute molecules *onto one side* of a semipermeable membrane in order to develop a *net flow*. Such a *new osmosis* flow will operate continuously in violation of the Second Law of Thermodynamics. (See Figure 6.)

To those who would instantly dismiss workability of the Figure 6 "Perpetual Motion Machine of the Second Kind," let them return to the Figure 4 osmosis simulator. *We can easily demonstrate workability* of new osmosis by *tethering* our simulated solutes to *one side* of the perforated paired lids. Since the solutes are *never diluted*, osmotic flow must continue as long as energy (in the form of macro-level shaking or *nano-level thermal motion*) is supplied. (See Figure 7.)

We now come to another Teachable Moment.

It is here that we can see how to stand "information theory" on its head as an argument disfavoring self-operating Maxwell Demon trapdoors. Recall Leff and Rex,[8] which gave lists of papers connecting information theory and the Second Law in a defeatist context.

The whole thing hangs on the following paradox: How can the membrane in the Figure 6 apparatus tell the difference

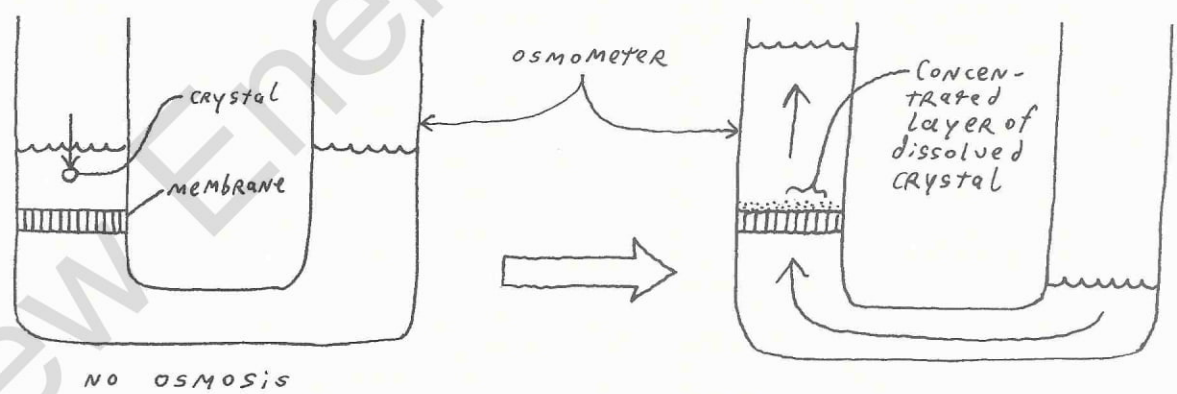

Fig. 5 : Osmosis begins when the impermeable solute formed by dissolution of the crystal diffuses into direct contact with one side of the semipermeable membrane. It slows to a stop as the solute disperses into the transferred fluid.

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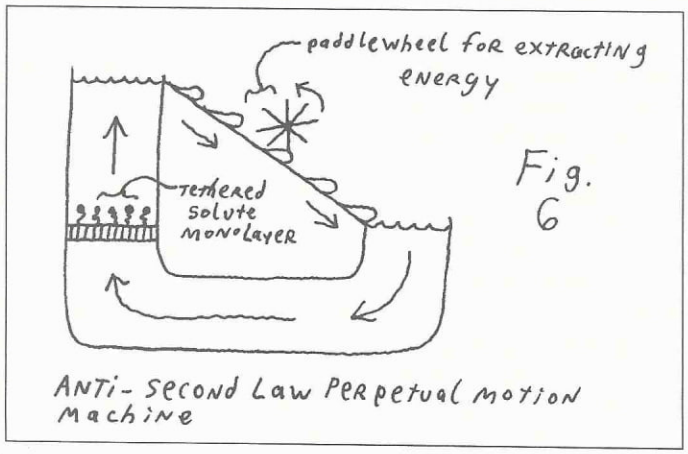

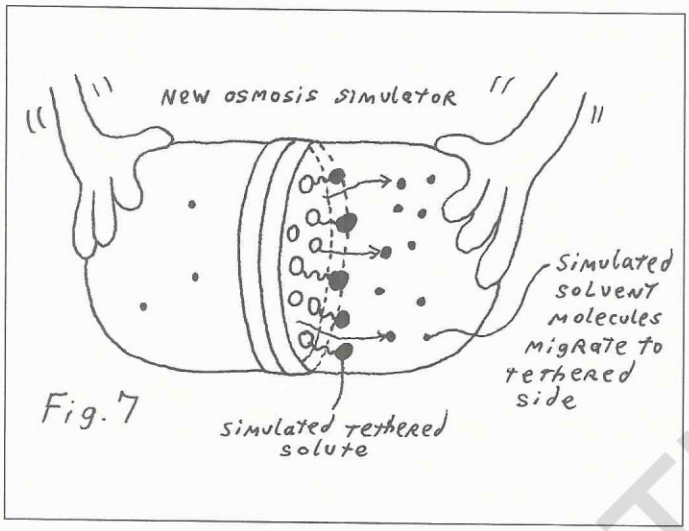

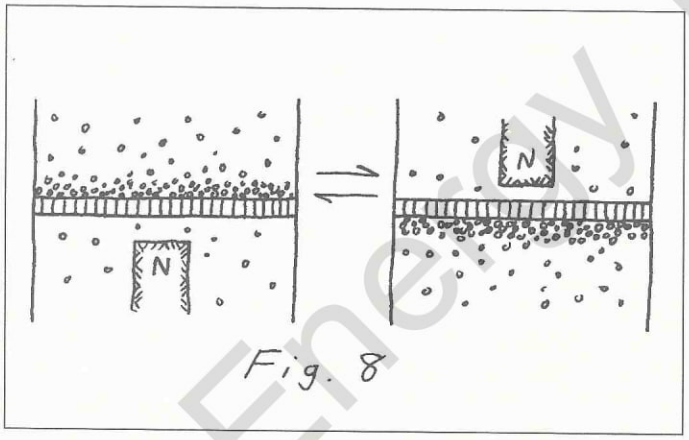

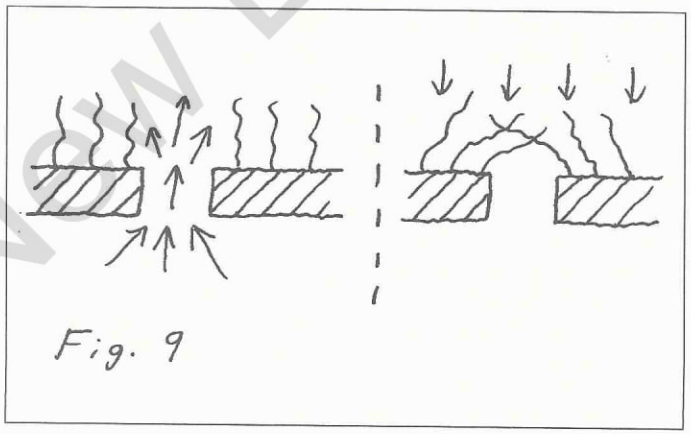

between tethered and untethered solute molecules (that effectively operate as crude trapdoors)? It seems (to my way of thinking) that the skeptic is forced into the unreasonable position to provide a mechanism to continuously warn the membrane to totally and forever ignore *only those solute molecules that are tethered* and only respond to the untethered molecules. To do this would unquestionably require a monumentally continuous input of information. Allowing anti-Second Law perpetual motion would be much easier!

To recapitulate on the papers that appeared in the Forum on Osmosis:[9] Regular osmosis can be considered to be a situation wherein the solute molecules are fully untethered and the *trapdoor interaction* they create that provides the observed flow can be considered self-limiting as the solutes disperse/self-dilute.

Having now "taken the high ground," I must consolidate my position.

There are those who reject any hope concerning the workability of self-operating trapdoor membranes on the basis of (okay folks. . .brace yourselves!) the presumption that any such trapdoors must be *actively cooled*!

I am not kidding about this. I have a 1992 reference that makes this very claim. Before I provide it, we must deal with the issue raised in the next paragraph.

To those of you working with the Figure 7 tethered-solute "new osmosis simulator," I ask the following question: What possible pathetic difference would it make to the operation of this device to refrigerate the too-big-to-pass-through-the-simulated-membrane simulated solute molecules? Another question is: Where does the breakpoint occur as you scale down the Figure 7 simulator? In other words, do you have to start refrigerating the simulated solutes when you get to the pollen grain size level? How about if you scaled it down so that virus particles would be good as simulated solutes? Is there any breakpoint at all? Don't you think the most reasonable conclusion is that Brownian motion actually could be used with uncooled *molecular* solutes held in place with *molecular* chain/tethers?

The reference that claims to offer a case for trapdoor cooling is Skordos and Zurek.[16] The authors state that their computer simulation backs them up regarding their conclusion. I don't have the time to sort through where they made their mistake. In general, we do know for sure that computers are extremely brittle devices. Just ask anyone who worked on the so-called "Y2K" or "millennium bug." Garbage in, garbage out.

A question that is more difficult to answer is: "Why didn't someone think of tethered-solute osmosis perpetual motion before?"

In reply to such an inevitable question, I can only say that *perhaps it was*, but in our peer-reviewed scientific culture, any submitted papers concerning such a possibility were firmly *rejected*. As one literature search starting point, it is not obvious to me where in any of the twelve reprints of early, classic papers dealing with membrane diffusion and osmosis[17] a person might locate such a technical precedent.

A paper that talks extensively about internal motions in polymers (as it applies to diffusion through synthetic membranes) does not address new osmosis.[18] The same is true for a report having information on the "flickering" nature of the free volume within a polymer in the context of explaining diffusional jumps of permeant molecules.[19]

What might be regarded as a "close call" on a report of

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new osmosis is Hammel and Scholander.[20] This report shows a figure highly similar to Figure 8.

The reference associated with Figure 8 shows measurement of osmotic force across a membrane with a ferrofluid medium and magnet on one side or another.

A reader-experimentalist will be interested to know that there are many literature reports having something to do with the covalent attachment of molecules to membranes. These are commonly called "grafted membranes." Nevertheless, no tethered solute new osmosis anti-Second Law perpetual diffusion is reported.[21,22] The last reference discusses, in part, an entrance valve that acts as a diode. It is formed by grafting chains onto one side of a porous material. (See Figure 9.) Brownian/Demon implications were not discussed.

Perhaps the closest set of papers I can arrive at that deal with the subject at hand are concerned with a model of a natural membrane system in which a molecular "ball" is tethered by a molecular "chain" to one side of the pore of a membrane protein in the manner shown in Figure 10.

Work using site-directed mutagenesis[23] appears to confirm a thirteen-year-old model.[24]

For related work on monofunctionalizing protein pores with clumps of molecular stuff, see Howorka *et al.*[25]

It is necessary for somebody, somewhere to someday provide actual experimental proof that molecular "balls and chains" on one side of a membrane can be used to harness random molecular motion. The following reference information and general suggestions are meant to be utilized by responsible and enlightened readers who happen to have greater resources in terms of access to laboratory equipment and financing than this writer.

A reader-experimentalist should know that an excellent starting point would be to utilize commercially available surface monolayer-treated synthetic membranes. For a report, see Singh.[26]

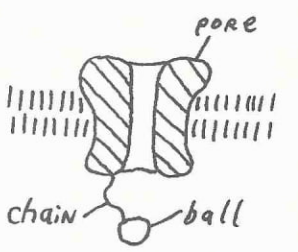

Fig. 10

Of interest in the present context is a U.S. patent assigned to a membrane company.[27] It specifically calls for treating only the surface of a membrane with hydrophilic amide groups that in turn can be used to immobilize ligands for affinity chromatography.

The means by which polymer surfaces can be chemically activated go beyond the scope of this report.[28] It is within the scope of this report to state that close up views of commercial membranes show a very rough profile on the Angstrom size level.[29,30] Accordingly, I suggest here that whatever surface activation method is used involve some type of "penetration-controlled reaction." This in turn implies use of reagents immobilized on bulky, colloid-size polymers.[31-34]

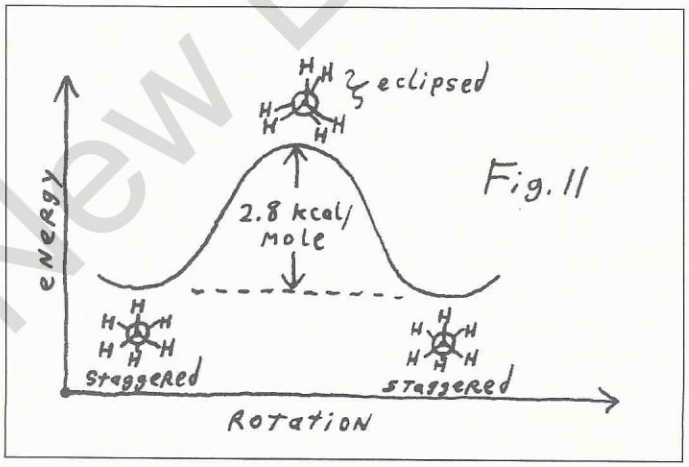

Fig. 11

I am now convinced and I assert here that the main thing we must do right with respect to creation of one-sided ball-and-chain tethered solute membranes is to use chains that are *intrinsically* as loose as possible. We can and must do better than to use alkane polymers as chains. Alkanes are actually quite stiff. For example, it is reported in Brown *et al.*[35] that: "In the very short alkanes such as butane, the molecule rotates nearly as a rigid body."

The baseline example of ethane is well-known to show an energy difference between "staggered" and "eclipsed" conformations of 2.8 kcal per mole. See Figure 11, obtained from Solomons.[36] According to Solomons:

> *Several times every second* [emphasis added], the ethane molecule will acquire enough energy [from] thermal motion to surmount the rotational barrier and it will rotate through an eclipsed conformation. . . Most molecules will wag back and forth with their atoms in staggered or nearly staggered conformations. The more energetic ones will rotate through eclipsed conformations to other staggered conformations.

After learning what the equipartition energy value for freely-translating gas molecules at room temperature is, we might be surprised that there are any ethane conformation changes at all. This equipartition value happens to be only 600 calories per mole.[37] We know that from the Maxwell-Boltzmann molecular velocity distribution law that the 600 cal/mole room temperature energy value is simply a *median*. There will be a certain fraction of molecules with translational energies equal to or greater than the torsional energy of the single bond of ethane. How large is this molecular fraction? The answer (provided by Kauzman[38]) is quite illuminating:

> Only about 3% of the molecules have velocities in excess of double the most probable velocity, and only 0.05% have velocities greater than 3 ump [ump, as used here, is a bit smaller than the median velocity]. In one mole of gas, only about 100 molecules move with velocities greater than 7 ump. . .

We may safely conclude from the above-given information that the use of a carbon-carbon alkyl bond as a pivotable trapdoor membrane connection would give us an extremely stiff hinge. The kinetic theory of gases teaches that at one atmosphere, a surface area measuring 3.5 Å in diameter will experience on the order of four billion gas molecule collisions each second. Yet, because of the rotation barrier problem, only a tiny fraction of these impacts will be able to shove past an alkyl-linked solute-trapdoor at room temperature. This helps us to understand why individuals working with grafted membranes have not reported any spontaneously-occurring pressure drops.

There is an easy way to obtain chain-tethers made of units having *zero* rotational barrier (providing the ultimate in diffusional freedom). Simply incorporate *acetylene junctions*

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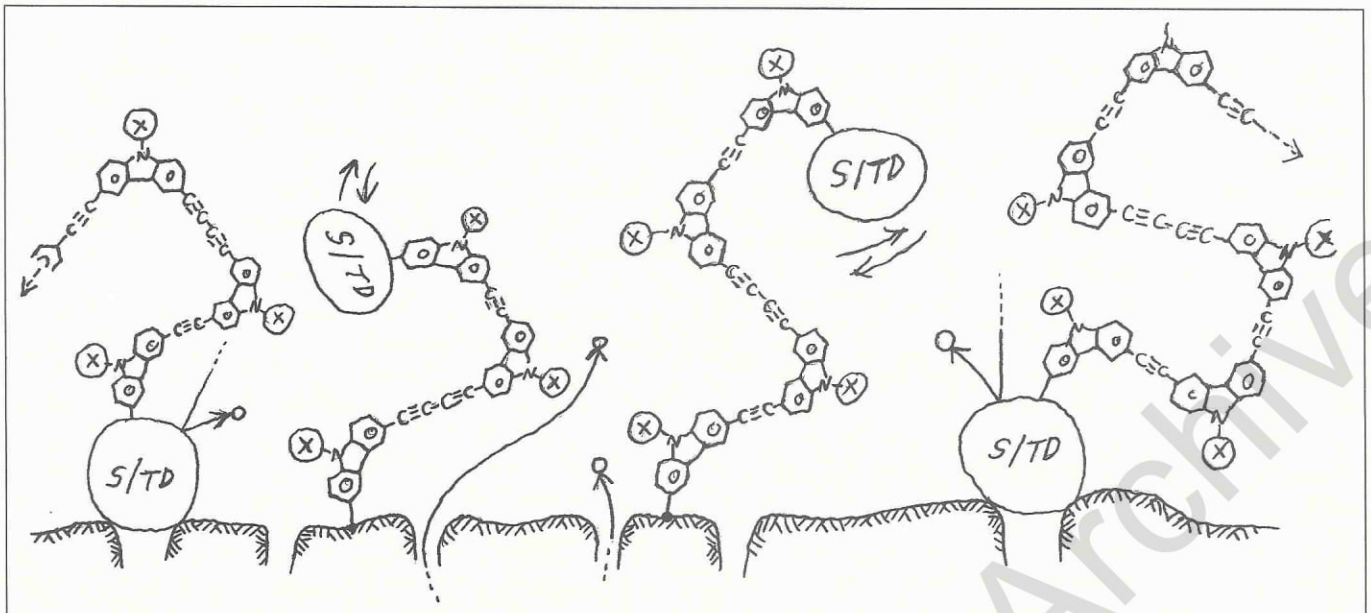

Fig. 12 S/TD = solute/trapdoors

The Equivalence Principle of New Osmosis: A Membrane Cannot Tell the Difference Between Tethered AND Un-tethered Solute Molecules

into the tethers. References on the long-known zero rotation barrier of acetylene-containing compounds are given henceforth.[39-43] Of related interest are Pitzer[44] and Orville-Thomas.[45]

Figure 12 shows a membrane surface monolayer of what I consider to be plausible acetylenic tethers connecting bulky solute/trapdoors ("S/TD"). The figure shows both "tolan style" and conjugated diacetylene junctions. Either junction is assumed to provide a zero rotation barrier.

The tether chains of Figure 12 incorporate 3,6-difunctionalized carbazoles. These act as 90° joints that promote free-swinging angularity. The needed carbazole-acetylene chemistry has recently been reported in connection with synthesis of square macrocycles.[46] Also of interest is a recent review of methods for making conjugated diacetylenes.[47] Brandsma wrote a 321-page book titled *Preparative Acetylenic Chemistry*.[48]

The N-connected "X" groups on the carbazoles will be chosen to inhibit any self-assembling "foldamer" interactions.[49-51] Aryl stacking is a primary driver of this.[52,53] Besides proper selection of N-functionality, there is excellent reason to believe that proper solvent selection will be effective in further suppressing foldamer-style aryl stacking.[54] The chains must stay loose and limber.

The nature of the solute/trapdoors (S/TD in Figure 12) is perhaps not extremely critical. We could select from a wide range of bulky organic functions. The list includes polyphenylated benzenes,[55-57] monofunctional dendrimers,[58-62] and phthalocyanine derivatives.[63,64] The highly colored nature and fluorescent properties of the latter compounds could be useful to chemists insofar as facilitating the verification of surface functionalization.

For the purpose of simply demonstrating the basic idea, the Figure 12 set-up should be experimentally adequate. A project for the future might be to devise membranes having trapdoors with a more optimal configuration. We can take as a baseline inspiration for improved trapdoors the "molecular turnstile" (Figure 13) of Bedard and Moore, reported in 1995.[65]

As an improved porous substrate for mounting more rationally-designed trapdoors, a person might use membranes consisting of fused masses of highly expanded dodecahedrons[66] or crystalline foam.[67]

If the above mechanism for deriving sustained fluid flow from random molecular bombardment is confirmed, the rhetorical floodgates would be opened. If there is one way to do such a thing, there might well be half a dozen or more ways. The situation should be analogous to what happened after the first laser was constructed in 1960. The initial solid-state device (based on ruby crystal) was soon joined by other

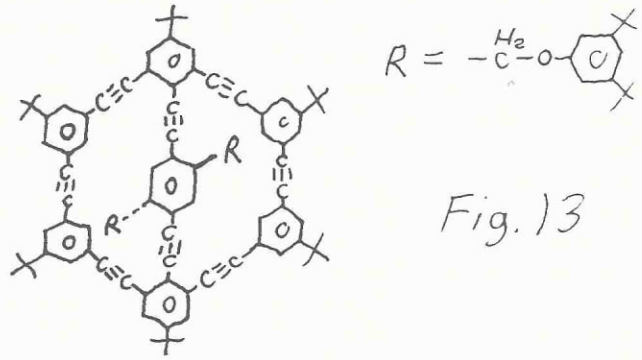

Fig. 13

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laser types using "gain media" based on semiconductors, plasmas, liquids, and gases. Also bear in mind that the principle of the laser was known for at least fifty years before someone finally used optical fabrication methods, that were also at least fifty years old, to build the first device.

The spirit of the above remarks finds expression in the following quote attributed to Roger Bacon:

> In accordance with the few examples which I have granted to nature and art, we can deduce several things from the one thing, the whole from its parts, and the general from the particular. (*Epistle on Miracles*)

A quote from Mauro[68] concerning momentum transfer in osmosis helps to inspire another Second Law violation demonstrator:

> . . .there must be a momentum deficiency in the micro-domain of the pore [on] the solution side of the [semipermeable] barrier. That is, in a solid region of the barrier, the time average transfer of momentum is that prescribed by the hydrostatic pressure of the phase, but in the opening of the pore there is a deficiency since the momentum arising from the [solute molecule] is not transferred to the solvent species in the pore, being cut off by the finite size of the pore. Thus, within the pore and only within the pore, a gradient of pressure arises and. . .flow ensues from the solvent side to the solution.

If we allow ourselves the boldness to consider the possibility of *reversibly manipulating through a catalytic operation* the *size* of solute molecules on one side of a membrane, a second type of new osmosis appears possible. It would certainly (borrowing from the quote above) provide a new way to ". . .not transfer [momentum] to the solvent species in the pore."

I need to state here that a type of existence-proof analogous process has been reported. The reader is referred to a 1993 article on a "Brownian Ratchet."[69] In this article, a number of mechanisms for protein transfer through a membrane pore were discussed that all operated (in one way or another) by making the protein bulkier on one side of said pore.

Of special interest in the present context is the base-induced thiazolium salt dimerization reaction described in Vandenberg *et al.*[70,71] and illustrated in Figure 14.

By grafting a monolayer of trialkyl amines onto one side of a membrane that is in contact with a solution containing the dimerizable thiazolium salts, the greater bulk of the dimer should assure a concentration build-up on the amine side (Figure 15).

In principle, any system in which the immobilization of a "dimer-monomer equilibrium shifting layer" in the presence of a solvent containing solutes that lend themselves to a dimer-monomer equilibrium shift by such a layer is fair game for use in the Figure 15 "isomer ratchet" membrane. I cannot claim priority for the *basic idea* for the Figure 15 ratchet.

Patlak[72] mentions a transport model—clearly labeled as a Maxwell Demon—able to achieve transport by triggering a favorable isomerization on the part of the molecule being transported (noted first on page 292 of the reference of note). In a subsequent paper,[73] the author honest-to-goodness *apologizes* for daring to label a putative membrane transport mechanism a "Maxwell Demon." Let us hope the Great Second Law God does not become angry enough to throw a lightning bolt!

A further Second Law violation concept is embodied in various U.S. patents assigned to Daniel H. Deutsch of Pasadena, California. Four patents are or primary interest. The first patent[74] discloses membranes with interconnected oriented voids allegedly able to provide a diode action. See Figure 16.

The Figure 16 membrane is said to be able to move fluids without the need to expend energy. It is claimed that fluids need not have any concentration difference (nonosmotic) to be moved. It is further stated that with rod-shaped molecules/solute particles, the membrane is especially effective.

The second patent[75] proposes use of cone-shaped Brownian particles. See Figure 17.

The Figure 18 manifold with tubes having tapered nanoholes can be found in another U.S. patent.[76]

The fourth and final Deutsch patent[77] shows a series-stack of plates with tapered holes, as illustrated in Figure 19.

In an article in a little-known scientific publication,[78]

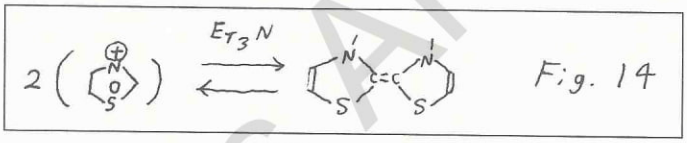

Fig. 14

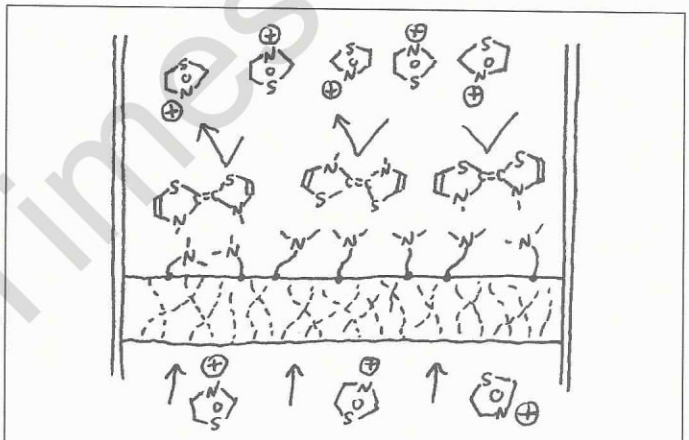

Fig. 15

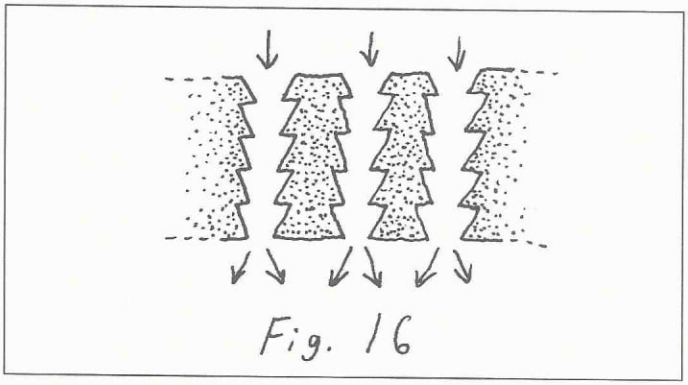

Fig. 16

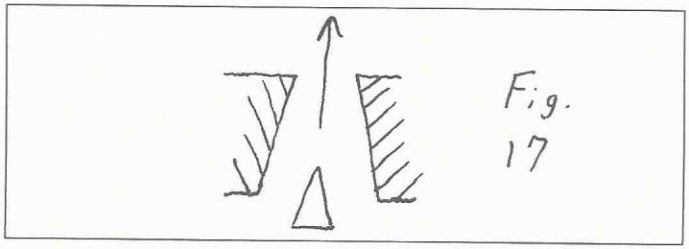

Fig. 17

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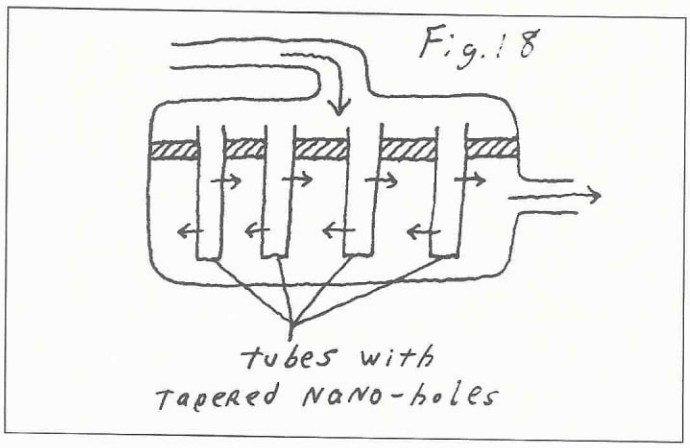
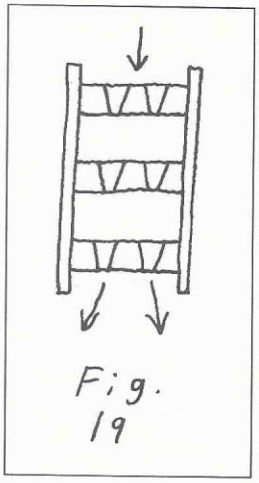


Deutsch rather skillfully defends his "tapered hole/tapered Brownian particle" concept. He attempts to prove the workability of his method of Second Law circumvention by supplying instructions for making a macro version of the Figure 19 tapered hole device. He calls it a "Negative Entropy Trap™." After filling it with test particles and then shaking it, the particles migrate to one end. The Negative Entropy Trap™ is Deutsch's version of my Figure 7 new osmosis simulator.



One source of corroboration for the insights of Deutsch might be the Japanese work that shows very tiny, micrometer-scale silicon-etched actuators that use vibrational energy in the environment.[79] The reference shows a "Deutsch-effect" ratchet device (Figure 20).

Clearly, we would prefer to reduce the dimensions of the Figure 20 mechanism by at least two orders of magnitude. This will better enable us to "get in between the nonuniformities."[80] Tempering this need is the fact that even if we did, we would be faced with the same massively-parallel "output summing" problem discussed in connection with ether micromechanical concepts that use conventional thermodynamics.[81] This appears to relegate us to some type of membrane approach wherein we have inherent summation.

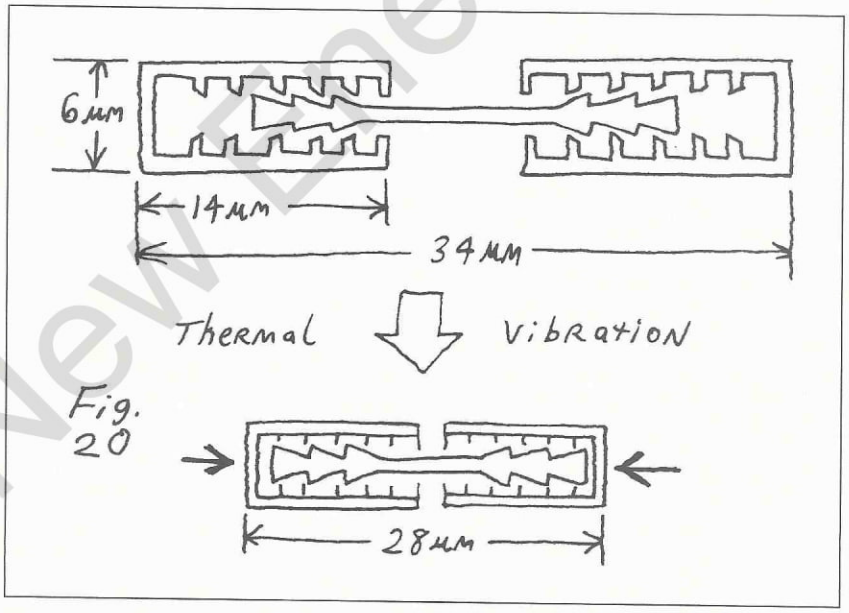
For a 1967 "funnel barrier" membrane report that gives no objective proof as to the workability of its subject matter, see Reference 82. If the Deutsch patents had been taken seriously when they were issued (in the early 1980s), a sharp patent lawyer could have seized on the 1967 disclosure as prior art that brings into question the novelty of said patents.

Searching further for molecular-level validation of the tapered hole membrane idea, we come across a 1980 paper that appeared in *Science*.[83] This appears to disclose the biological equivalent of Deutsch's funnel barriers. Apparently, as judged from my reading of this article, concentration gradients are not required for cross-membrane diffusion. Unfortunately, the language is opaque (to me at least!).

In view of the lack of molecular-level experimental proof of the general "Deutsch proposition," I have decided to propose here a reproducible demonstration to confirm or deny what amounts to the same basic idea. The demonstration will require a membrane made of linear molecular structural elements. The need could be satisfied using membranes made of expanded molecular dodecahedrons.[66] Figure 21 shows a monolayer version of such a membrane.

The membrane is sandwiched between electrified porous grids. The electric field orients V-shaped polarized molecules. The basis for expecting biased motion on the part of such molecules is this: when a random Brownian impulse tries to shove them downward, the open ends tend to get hung up on the linear elements of the molecular cages that constitute the Figure 21 membrane. Upward progress is much less inhibited owing to what I hereby designate as an "arrowhead effect."

Before presenting ideas for polarized, arrowhead-shaped V-molecules suitable for testing in the Figure 21 apparatus, we must understand the degree to which this simple idea represents a venture into the unknown. It so happens that there is almost no information on how friction between rubbing surfaces varies depending on the relative orientations of the molecules on the respective surfaces. The situation is summed up in a quote from Brown:[84] "Very little is known about the slip of a mobile. . . material on a rigid material, even for the simple situation considered here, where the interaction between the materials is mainly by dispersion forces."



Somewhat more helpful is a reference that discusses experiments performed with an Atomic Force Microscope (AFM)[85] in relation to scanning along and perpendicular to organized rows of monolayer molecules arranged like rows of corn. The workers reported that AFM scanning along the rows gives rise to the least friction, whereas perpendicular scanning offers the greatest resistance to the sliding of the AFM tip.

One idea for a molecule that is closed at one end and open at the other ("V-shaped") is shown in Figure 22. A German language reference is Hartmann *et al.*[86] Also see Ruf *et al.*[87]

Figure 23 shows another "tripodal" arrowhead candidate, noted in Amoroso *et al.*[88] I expect that the Figure 22 and 23 compounds will be highly colored. This should assist mon-

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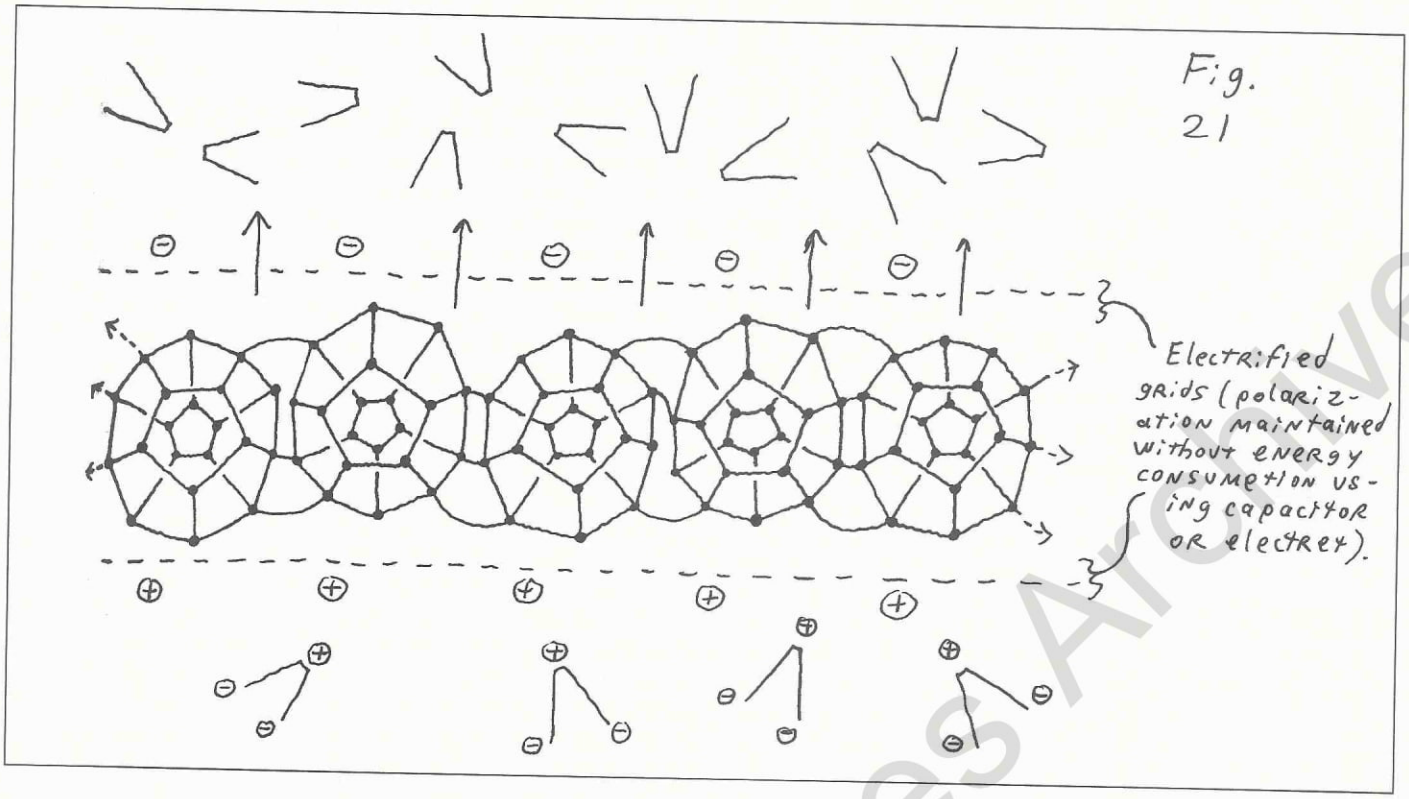
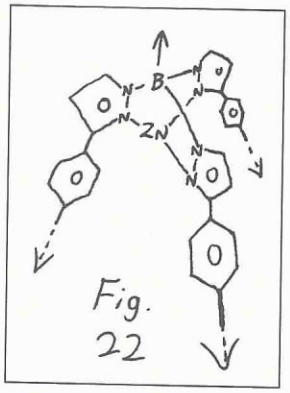
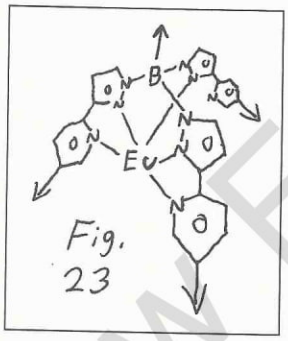
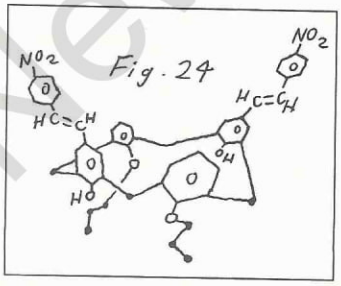








itoring the progress of any Deutsch diffusion as the solution on one side of the Figure 21 membrane gets fainter and the other side becomes more deeply colored. "Tetrapodal" arrowheads based on calix [4] arenes could take many forms. Figure 24 shows one example that is *already polarized.*

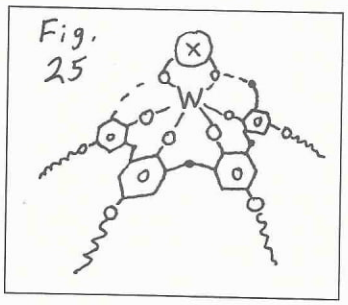
This molecule was reported in 1998.[89] For earlier work on polarized nitro calix [4] arenes, see Keiderman *et al.*[90]

An excellent, high-yield method for making the calix [4] arene tetrapod arrowhead precursor of Figure 25 is reported in Xu *et al.*[91] A similar tungsten-capped compound was reported in 2001.[92]

Finally, other arrowhead precursors might very possibly be recruited from the ranks of so-called "bowlic" liquid crystals.[93-96]

The foregoing discussion of the Negative Entropy Trap™ of Deutsch and my own conceptual polarized arrowheads would be looked down upon by the keepers of the truth of conventional science.

The attitude of modern science toward fabrication of such machinery is summarized by a quote from a 1997 article that appeared in *Science*:[97] "Structural features alone, no matter how cleverly designed, cannot bias Brownian motion." The author claims that only "non-equilibrium fluctuations" can operate a Brownian motor.



The particular type of molecular ratchet discussed in Kelly *et al.*[2,3] would appear to validate the above quote. The molecule of note is shown in Figure 26.

The rotation energy curve of the Figure 26 molecule is steeper on one side than the other. Supposedly, this is the sine qua non requirement for harnessing random molecular motion and tearing down the Second Law. Nevertheless, convincing evidence is provided in Kelly *et al.*[2,3] that the triptycene component rotates clockwise and counterclockwise *to the same extent.*

My own view of the negative results is that if you built a macro-sized model of the Figure 26 molecule and placed this model in a Figure 27 shaker chamber filled with test particles simulating a Brownian fluid environment, the result would be the same: no net rotation.

Any person with half an ounce of sense should not be surprised by the negative outcome.

Those of us who are mature have learned that in all endeavors in life there is at least one right way for every wrong way. I propose to the reader that the same is true here. My research turns up the fact that macrolevel equivalents of truly useful molecular designs have been in the public domain for many decades.

By searching in U.S. patent class 185, subclass 30 (motors,

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irregular motion), I have found a particular patent[98] that describes "paddle-wheels and helix vanes. . . extending into the path of one or more balls. . .free to move on the floor of a casing." The patent specifies that the casing may be freely vibrating or oscillating. Also, ratchet and pawl devices are mentioned in the above patent as a way to assure one-way motion.

The patent of note was issued on October 11, 1911. The whole idea behind this contraption was to renew an advertising message connected to the rear bumper of a car. It appears that the roads of that era were so bumpy that the inventor felt that there would be no problem getting enough random energy to move "one or more balls. . .on the floor of a casing" in order to rotate said message!

In consideration of the above, I recommend that a more fruitful molecular design be based on the rotaxane association of a triptycene with a bridgehead axle passing through the center of a "Lockwasher molecule." This can be simulated using the apparatus in Figure 28.

The formal designation for the Lockwasher molecule is helicene. Helical molecules have been around for many years. There is at least one review in case the reader wishes to follow up on my proposal.[99]

It may have already been proven that helical molecules can display one-way rotation when subject to random molecular bombardment. My basis for optimism is a report that appeared in *Science* in 1998[100] and which analyzes the behavior of propeller-shaped hexa-tert-butyl decacylene (HB-DC). See Figure 29.

The figure symbolizes a key observation: scanning tunneling microscope (STM) images clearly show torus-shaped surface entities scattered within regular hexagonal shapes. The interpretation is that the ring-like entities are actually rapidly spinning hexagons. The reference of note argues the point further:

> . . .we demonstrate the. . .realization of single-molecule rotors surrounded by like molecules that form a supramolecular bearing. Evidence of their high-speed rotation, *driven by thermal energy at room temperature* [emphasis added] was obtained by means of scanning tunneling microscopy (STM). . .Rotation [occurs] at low symmetry sites and is controlled by supramolecular interactions of the molecular rotor with a bearing formed by the surrounding molecules.

After absorbing the contents of the last few paragraphs, a reader with experience in the art will draw an immediate connection to the "Feynman Ratchet."

Physicist Richard Feynman has reasoned that the Figure 30 ratchet-and-pawl machine will not work if it is scaled down to molecular size. Specifically, Feynman is reported to have said that when temperatures in "T" and "T_2" are equal, the machine cannot operate. Despite such assurances, at least one small crack in the peer-reviewed literature has appeared.

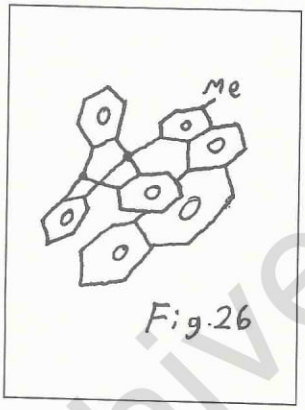

Fig. 26

As one criticism, a 1996 paper[101] brings up the fact that macroscopic fluctuations (such as wrist motion) can be used to drive self-winding watches. For my part, by way of supporting nanoratchets, I would like to take this time to inform the reader that the last time I looked, a person could find plenty of self-winding watch designs in the patent literature by looking in patent class 58 (horology), subclass 82 (self-winding watches). What is wrong with self-winding *nano*watches?

For the sake of completeness (and to hopefully add further insult to injury), I conclude this paper with a handful of additional anti-Second Law ideas.

In my literature searching, I have noticed proposals for "self-rectifying diodes." Such devices could act as a source of electricity by performing a Demon-like trick on the "electron gas" present within solid metals.[102] Another reference[103] is paradoxical in that it seems to give clear evidence for such a process but then concludes by using what are in my view contrived means to dismiss the possibility of getting free energy from electrical noise. In the above context, the quote at the end of McFee[104] is considered highly significant: ". . . it does appear that the conflict between diode the-

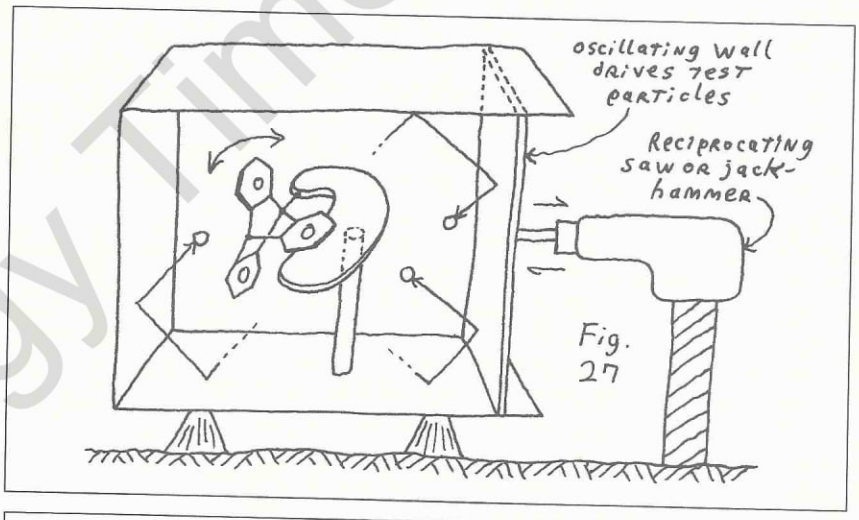

Fig. 27

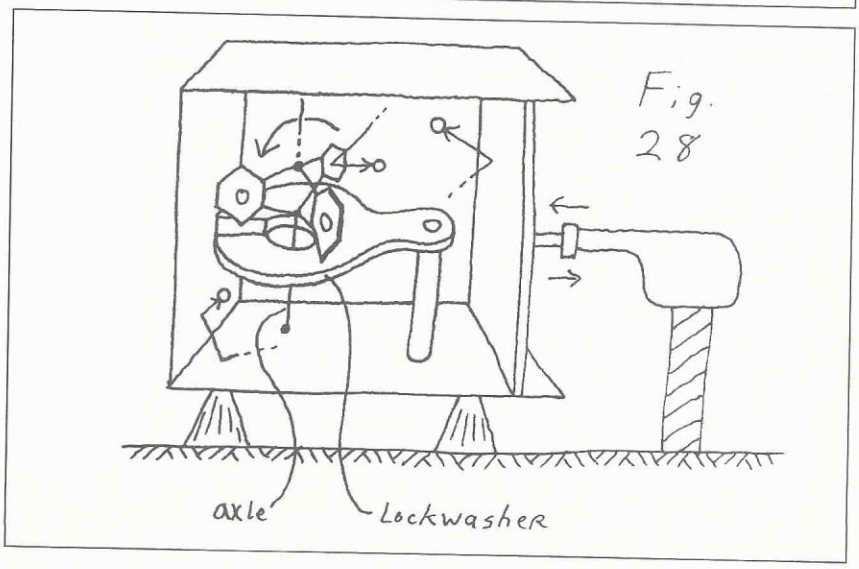

Fig. 28

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ory and the Second Law has yet to be resolved."

The most recent work (appearing in a 1999 paper[105]) seems to require "biased white noise" on the part of the electron gas.

Molecular diodes (of conventional type) do appear possible according to Metzger.[106,107] Such tiny diodes *might* be effective when it comes to implementing a novel Brownian motion harnessing concept that appeared in *Thermodynamics for Chemical Engineers*.[108] The following is a quote from this 1939 book:

> Boltzmann suggested another technique which avoids any necessity for intelligence in the actual operation of the [Maxwell Demon] process. Assume a cell containing an extremely dilute solution of colloidal iron. Place this between the poles of a permanent magnet having poles of dimensions approximating those of the iron particles. The magnet is provided with a coil from which a current developed by the Brownian movement of the iron particles past the magnet coils can be drawn. To maintain the colloidal motion (hold the temperature constant) the whole may be immersed in the ocean, which serves as a reservoir from which to draw heat energy. The sole net result of operating this system would be the conversion of a quantity of heat to work—an impossible result according to the Second Law.

I note here that the above words were written at least two decades before the first ferrofluids became commercially available. In case anyone wants to follow up on the above-given 1939 idea, it would be of interest to know that the magnetic field due to a 30 Å Fe_3O_4 particle at a distance of 20 Å is approximately 1000 Oe.[109] Also, information on single-molecule conductors can be found in Joachim.[110]

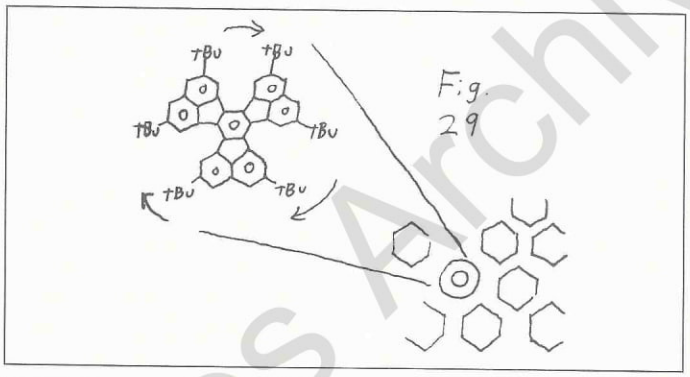
After everything shakes out and all the dust settles, I suspect that the destruction of the Second Law will be greeted with open arms if only from a purely philosophical standpoint. There are many informed scientists who are uncomfortable with the fact that this "Law" is based purely on negative proof; you cannot prove that something cannot be done. Klein[111] deals with the historical development of the Second Law. The paper remarks on the great difficulty the scientists of the late nineteenth century had in *proving* that perpetual motion of the second kind is impossible.

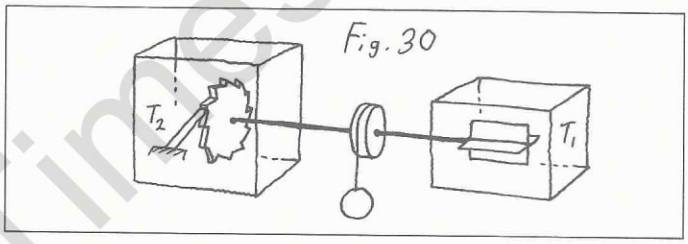
I conclude this paper by putting forward the opinion that the best way to implement anti-Second Law power generators is to use a membrane-based system. After it is experimentally proven, the basic Figure 6 machine seems (in my opinion) to warrant maximum development attention. The final quote in this paper, from Primavesi,[112] is highly germane to the issue of reduction-to-practice:

> This brings us to practical difficulties, which could be enormous. It would probably require very sophisticated synthetic chemistry to produce a membrane. . . for a test. It would probably require some courageous large company, institute, or government to do the preliminary work. The outcome would be very uncertain. . .it [might] work but produce only one mouse-power per km^2, or it could, just possibly, provide us with an inexhaustible source of power.

Epilog

In the Middle Ages, it was proof enough to simply declare: "The Earth is flat because Aristotle says so!" In the new age of molecular nanotechnology, we can finally rise above authoritarian thinking concerning the thermodynamic "flat Earth theory" of the Second Law. The Second Law theory has not been subjected to *anything like* the experimental challenges that all the other theories of science have been exposed to (Newton's Laws, quantum mechanics, relativity, etc.). We must overcome our culturally ingrained "mental block" when it comes to the realization of *perpetual motion machines*.





About the Author

A primary lesson that Kevin Varner learned during his school years in the 1960s is the value of self-motivated/self-study, which is the main reason why he scored 13 points above the 99th percentile on the eleventh grade Minnesota chemistry test in 1970. He has learned much more chemistry in the years since. Varner's official education ended with his graduation from Ogilvie High School in 1971. He explains, "I am not a 'math-type' person. I know full well that in order to get any kind of technical degree, you must embrace the 'cult of computation.' It so happens that equations can obscure things more than they illuminate. A very good example of this can be found with literature treatments of osmosis. The equation writers can take a perfectly simple thing like osmosis and turn it into a bloated, unrecognizable blob! This could be one reason why a simple thing like tethered-solute osmosis evidently lay undiscovered for much too long." In addition to his chemistry observations (see classified ad concerning nanotechnology, *Discover*, February 2002), Varner has had a long-term interest in energy issues. His windmill experiments resulted in the publication of a 70-page book in 1979 and his solar energy experiments culminated in the issuance on U.S. Patent 4,488,779 in 1984 ("Lightweight Heliostat System"). Varner sells his abstract drawings on the internet at www.artcrawl.com.

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Comments on Tethered Solute Osmosis

Ken Rauen
NERL Senior Scientist

As a researcher in thermodynamics and a challenger of the Second Law, I find the basic content of Kevin Varner's hypothesis to be acceptable. I do have a few modifying comments which will add more light to the subject. Mr. Varner's macroscopic effect Maxwell's Demon demonstrator is not a perfect parallel to the microscopic realm. His demonstrator does exhibit rectification of random motion, but the rectification of atoms and molecules cannot be deduced from this demonstration.

The reflection of a spherical ball off of a flat surface does not apply to the motion of fluid atoms or molecules at a solid boundary. On the atomic level, flat surfaces are not flat. Impinging particles are likewise not spherical. The reflection angles used in macroscopic sorting methods of moving particles do not apply at the molecular level. Experimental evidence supports this. Herbert Johnson, a retired professor of mechanical engineering at the University of Colorado, researched a Maxwell's Demon concept and built a working model which produced positive results, according to documents in our possession. His invention can be called a "gas diode." His paper, "Biased Vector Engine-Refrigerator," was originally presented for publication and presentation at a conference of the American Society of Mechanical Engineers (ASME) in 1983. The paper was rejected without full review, due to its nature. Among his references were the experimentally measured rebound angles of gases off of a polished surface from various impinging angles. Scattering was observed, not reflection, even in a vacuum.[1] This shows there is no correlation between macroscopic and microscopic motion at a boundary.

It is my opinion that Mr. Varner's hypothesis cannot rely upon macroscopic models as evidence. His device may work, but for reasons other than asymmetrical reflections of moving molecules.

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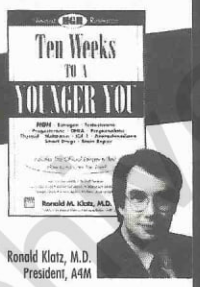

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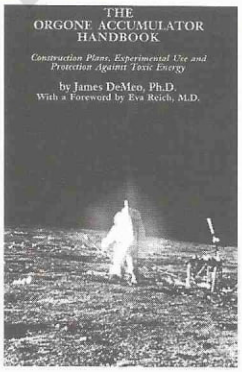

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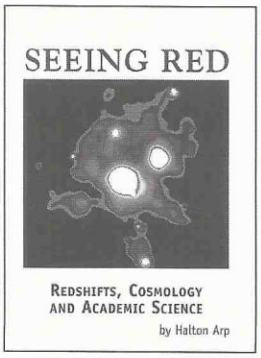

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Status Reports on Technologies and Claims

This is a continuing series of updates on the activities and achievements of new energy companies, organizations, and inventors.

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Dr. Paulo Correa and Alexandra Correa
42 Rockview Gardens
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Brief descriptions of new energy and bioenergy inventions by the Correas may be found in several new "Letters of Support" at the Correa website [http://www.aetherometry.com/letters.html], offered by Dr. Eugene Mallove, Uri Soudak, and Professor Arthur Axelrad of the University of Toronto. These include:

1. A Stirling engine that runs off of the thermal anomaly within an orgone accumulator (previously detailed in *IE* #41 and 42).
2. Capacitor or battery charger having *no electric power* input (no wall power connection or battery).
3. Aether Field Meter.
4. "Perpetuum Mobile" Wheel.

These devices are designed to be concrete demonstrations of the aetherometry physics and biophysics discussed by the Correas in the scientific monographs on their web site.

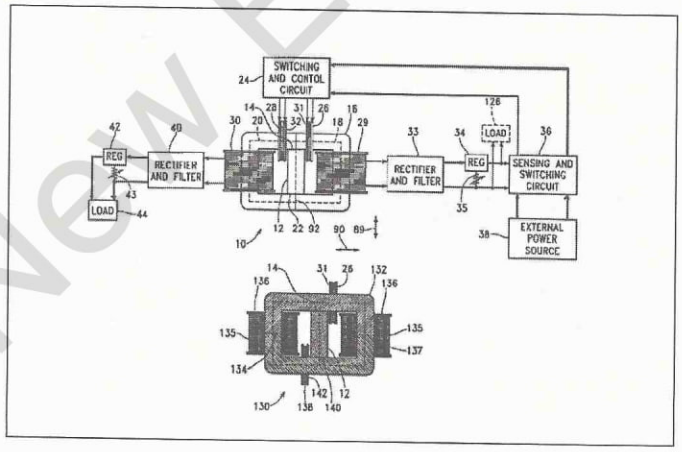
Magnetic Energy Limited

Dr. James Lee Kenny, CEO
925 Tascosa Dr.
Huntsville, AL 35802

The company's "Motionless Electromagnetic Generator" (MEG) received an historic United States patent, U.S. 6,362,718, on March 26, 2002:

Motionless Electromagnetic Generator (MEG)

Abstract: An electromagnetic generator without moving parts includes a permanent magnet and a magnetic core including first and second magnetic paths. A first input coil and a first output coil extend around portions of the first magnetic path, while a second input coil and a second output coil extend around portions of the second magnetic path. The input coils are alternatively pulsed to provide induced current pulses in the output coils. Driving electrical current through each of the input coils reduces a level of flux from the permanent magnet within the magnet path around which the input coil extends. In an alternative embodiment of an electromagnetic generator, the magnetic core includes annular spaced-apart plates, with posts and permanent magnets extending in an alternating fashion between the plates. An output coil extends around each of these posts. Input coils extending around portions of the plates are pulsed to cause the induction of current within the output coils.



Inventors:	Patrick, Stephen L.; Bearden, Thomas E.; Hayes, James C.; Moore, Kenneth D.; Kenny, James L.
Appl. No.:	656313
Filed:	September 6, 2000

The provocative first paragraph of the patent reads: "This invention relates to a magnetic generator used to produce electrical power without moving parts, and, more particularly, to such a device having a capability, when operating, of producing electrical power without an external application of input power through input coils."

On Tom Bearden's website, www.cheniere.org, he makes these assertions: "We have now secured an agreement with the National Materials Science Laboratory of the National Academy of Science in a friendly foreign country, to do the necessary advanced research to finish the MEG for scale-up and commercial production. The first commercial units should be rolling off the production lines in about one year, and we expect them to be closed-loop self-powering systems of about 2.5 KW output, but modular. So, say, four of them can be arrayed with a synchronization unit (under development simultaneously) to produce 10 KW output."

Jean-Louis Naudin's website contains additional information about the MEG and its testing:

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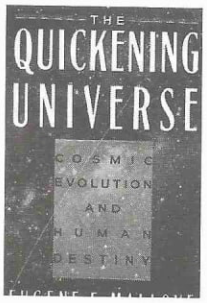

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The Quickening Universe:
Cosmic Evolution and Human Destiny

by Dr. Eugene F. Mallove

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Cold Fusion Technology • P.O. Box 2816 • Concord, NH 03302-2816
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Ken Rauen

Sonofusion

Nearly a year of testing of Roger Stringham's sonofusion process via commercially available Crest ultrasonic oscillator electronics has only sporadically produced excess heat, as documented in *IE* issues over the last year. Because of the vast amount of testing done with few positive results, I have given up on the Crest oscillator system. Positive results are too few and the system is far too unrepeatable to demonstrate the effect. I believe that NERL's reactor design may have something to do with the lack of success with the Crest oscillator circuitry, creating a detuned system. Our piezoelectric transducer design, which is significantly different from Roger's due to practical considerations, has higher resonances than Roger's, and the resonances are higher than the Crest operating frequencies. Changes need to be made to match an oscillator to the higher frequencies of our reactor.

Being such a small lab, what would be a routine shift of resources, a regrouping, is a major effort for us. Changes in materials and equipment are big changes for us. Our magazine sales and other revenue just barely pay our rent and our salaries. There is little left over for materials and equipment for the lab. Since the Crest oscillators are not working for us, our alternative has been to examine single frequency excitation via a signal generator and an audio amplifier. In order to do this, I have loaned one of my audio amplifiers to the lab, a Mackie M-1200, a two-channel professional sound reinforcement amplifier, rated at 600 watts per channel into 2 ohms, regardless of the load reactance.

The Mackie amplifier has a power bandwidth of 70 kHz, so it is well suited to sonofusion research, except for one detail. The voltage output is limited to 70 volts, peak. The Crest electronics produces 350 Vp. The technique of creating an LRC resonance by putting a coil in series with a piezo element boosts the voltage available to the piezo. Generally, I have observed a ten times increase in piezo voltage near 40 kHz with the 5 mH coils provided by Crest. This translates to 3.5 kVp for the Crest system, and 700 Vp for the Mackie. No one knows what piezo voltage is required for sonofusion to occur. The frequency and amplitude shifting of the Crest oscillator leaves these parameters uncharacterized. Chris Eddy of Pioneer Microsystems is continuing to help us and has arranged for some custom-made step-up transformers to be sent to us. While we wait, we have continued testing with our equipment on hand.

Many tests have been made with the 70 Vp limitation. Aside from NERL's standard reactor, two modified reactors have been made. The standard reactor uses Roger's cavity size of 2.5 inches in diameter with a gap between the piezo drivers of 0.25 inches. One modified reactor has only a 0.10 inch gap, putting the entire water volume at approximately the same acoustic pressure, being far below the quarter wavelength of heavy water in the 40 kHz range. The other has a 0.69 inch gap, corresponding to the half wavelength of heavy water at 40 kHz, hoping to see standing wave effects.

An impedance curve of a Crest piezoelectric transducer was published in Issue #40. Since we acquired a digital storage oscilloscope with computer-driven fast Fourier transform spectrum analysis, I have been able to plot impedance curves readily. I have found a bewildering variation of impedance which is influenced by air or water loading, the thickness of the water chamber, single or double transducer excitation, temperature, pressure, and other factors. The impedance curve shifts like wind-blown sand in a desert, plus multiple peaks and dips exist, far more than the 3 tangent wave-like spikes seen in the published graph (*IE* #40). Specific frequencies for uniform testing are difficult to select.

A wide range of tests have been done on all three reactors, with the 70 Vp limitation. Certain frequencies have been selected, based upon resonant or near-resonant conditions, where current is in phase with applied voltage at the input of the LRC circuit. One hundred percent amplitude modulation covers that one variable, up to 70 Vp. Argon over-pressure has been varied from 0 to 40 psig. Temperatures have not been regulated, but vary from room temperature to 80°C. Resonances have drifted with a change in temperature, and the oscillator frequency has been adjusted throughout each test. All results have been null, typically showing +/- 0.3 watts or less.

The next level of higher amplitude testing has been started with the addition of a 1:1 isolation transformer, two 5 mH coils on one ferrite toroidal core. This allowed the Mackie to be operated in bridged mode for a 140 Vp signal. The two channels are used to drive one load by driving the second channel with a reversed polarity signal. The load is connected to the "plus" polarity terminals of each channel, therefore providing a non-grounded, differential drive. The isolation transformer makes this compatible with the grounded wattmeter. Though testing by this method has just started with the 0.1 inch gapped reactor, all tests have been null so far. Much more can and will be done with various resonance points, plus the two other reactor types.

Maybe the step-up transformer will "put us back in the ball park."

We also have another option for higher acoustic amplitudes. Thanks to Jan Roos, my semi-retired, part-time lab partner who comes in about one day a week, another means is at our disposal. He recognized that two piezo elements can be used back-to-back in the same transducer

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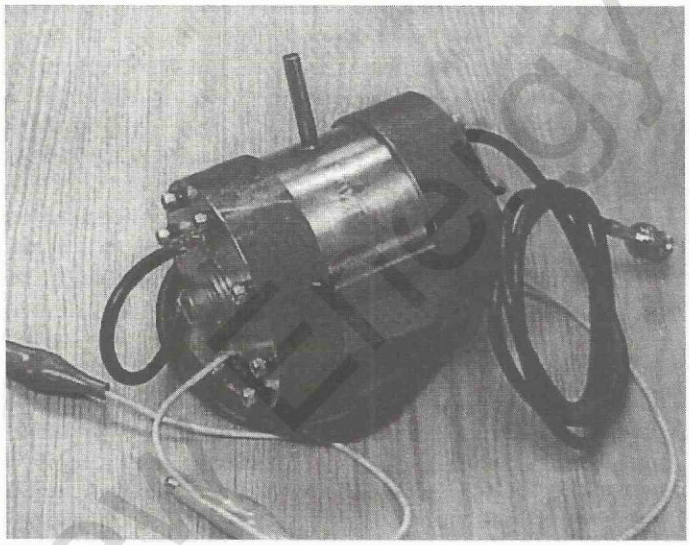
assembly with the same polarizing voltage for twice the acoustic amplitude. Two metal foils form the electrodes of a capacitor, for which a piezoelectric ceramic disc forms a dielectric insulator between the electrodes. Three electrodes with two piezoelectric discs form this new piezoelectric capacitor, with the central electrode as the hot terminal and the two outer electrodes as the grounds. The two piezo elements are axially oriented with opposite polarity, but when electrically polarized by the metal plates, produce mechanical strain in the same direction, thus doubling the acoustic amplitude. Preliminary testing shows this is a practical method.

Yet another option is a fourth reactor housing which was designed by computer finite element analysis for its vibrational behavior. A maximum axial amplitude was found for a different steel end cap support of the piezoelectric assemblies, increasing the available acoustic field even more. That has been machined and is awaiting lab trials.

Gene Mallove has arranged for testing for tritium of some of our past test water samples. He will be working with staff at the University of New Hampshire on a Packard 1600 TR liquid scintillation analyzer that is ordinarily used in radon studies, but which has the capability of accurate tritium counting too. This direction has been inspired by the sonofusion work at Oak Ridge National Laboratory, reported in *Science* (March 8, 2002).

Since I am the only full-time lab employee at the moment, and Jan Roos is here one day a week, I feel like a three-legged cat on a tin roof. And NERL has other, proprietary projects in development, which we are not at liberty to mention in public yet. There are good things to come. We just need more support to bring them to life in a shorter period of time.



This is a photograph of our latest design of a sonofusion reactor. It is optimized for maximum mechanical resonance to achieve the highest acoustic sound pressure level for a given electrical power input. Finite element analysis by computer was used to design the steel end caps which hold the piezoelectric elements and titanium reactor chamber faces. RG-58/U cable is used for adequate electrical insulation for the hot leads to the piezos. The single wires terminated with alligator clips are the ground connections from the piezos.

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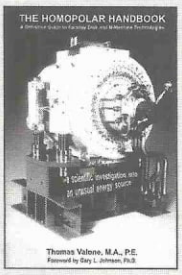

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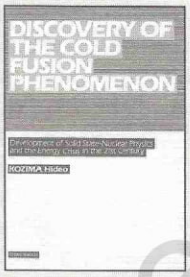

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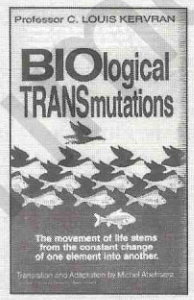

Biological Transmutations

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Dirac's Equation and the Sea of Negative Energy

PART 1

D.L. Hotson*

Preface

Dirac's Equation has profound implications both for science and for the search for new energy. If we continue to use the wrong model (and the Standard Model is profoundly wrong) we will continue to get confusing results that are difficult to replicate.

The enclosure shows the *nature* of the energetic, nonstationary aether that Einstein missed, that Dirac's equation demonstrates, and that Heisenberg and others destroyed when they dismantled this equation. It further suggests that special conditions, catalysis, and energy available to a plasma may cause the synthesis, rather than the release, of free neutrons, causing transmutations and the release of energy via beta decay.

The treatment of Dirac's equation is a lesson in the way modern science works (or rather doesn't). This treatment has more recently been paralleled by the treatment of Reich, Pons and Fleischmann, Halton Arp, and others. But I think if one had to point to a single place where science went profoundly and permanently off the track, it would be 1934 and the emasculation of Dirac's equation. This crisis at the heart of science caused a chronic "hardening of the paradigm" and science thereby lost the ability to self-correct.

Abstract

Dirac's wave equation is a relativistic generalization of the Schrödinger wave equation. In 1934 this brilliantly successful equation was shorn of half of its solutions by a questionable bit of mathematical slight-of-hand. Because it was "politically correct," this bit of juggling became the accepted interpretation. However, recent developments have shown the very basis of this mathematical trick to be invalid, in that it would involve massive violations of conservation. A reevaluation is therefore warranted.

The Schrödinger wave equation has been said to "contain most of physics and all of chemistry." Since Dirac's equation is a relativistic generalization of this already generally applicable wave equation, in formulating it Dirac expected that its solutions would describe "everything that waves." Since all matter and energy evolve as waves, Dirac thought his equation would be a unitary "theory of everything." However, the discovery of several new particles and peer criticism resulting in the truncation of the equation frustrated this expectation, and it is generally known at present as "Dirac's equation of the electron."

Dirac's *complete* equation, however, describes a quantum spinor field, which has as solutions four different kinds of electron: electrons and positrons of positive energy, and electrons and positrons of negative energy. Such supposedly "fundamental" entities as quarks and gluons have no comparable wave equations; yet they wave. Therefore they cannot be truly fundamental. Since in principle the Dirac field comprises "everything that waves," the equation therefore *predicts* that the entire physical universe can be made from these four kinds of electron. This study validates this prediction: all matter and all forces are shown to be necessary combinations and applications of just these four kinds of electron, fulfilling Dirac's unitary expectation.

In addition, direct applications of Dirac's equation provide simple, logical, and natural models of the electromag-

About the Author

The Hotson "family business" is English literature. Mr. Hotson's father and uncle had Harvard Ph.D.s in the subject, and his late uncle was a famous Shakespeare scholar. Mr. Hotson, however, always intended a career in physics. Unfortunately, he could not resist asking awkward questions. His professors taught that conservation of mass-energy is the never-violated, rock-solid foundation of all physics. In "pair production" a photon of at least 1.022 MeV "creates" an electron-positron pair, each with 0.511 MeV of rest energy, with any excess being the momentum of the "created" pair. So supposedly the conservation books balance.

But the "created" electron and positron both have spin (angular momentum) energy of $h/4\pi$. By any assumption as to the size of electron or positron, this is far more energy than that supplied by the photon at "creation."

"Isn't angular momentum energy?" he asked a professor.

"Of course it is. This half-integer spin angular momentum is the energy needed by the electron to set up a stable standing wave around the proton. Thus it is responsible for the Pauli exclusion principle, hence for the extension and stability of all matter. You could say it is the sole cause of the periodic table of elements."

"Then where does all this energy come from? How can the 'created' electron have something like sixteen times more energy than the photon that supposedly 'created' it? Isn't this a huge violation of your never-violated rock-solid foundation of all physics?"

"We regard spin angular momentum as an 'inherent property' of electron and positron, not as a violation of conservation."

"But if it's real energy, where does it come from? Does the Energy Fairy step in and proclaim a miracle every time 'creation' is invoked, billions of times a second? How does this fit your never-violated conservation?"

"'Inherent property' means we don't talk about it, and you won't either if you want to pass this course."

Well, this answer sounded to him like the Stephen Leacock aphorism: "'Shut up,' he explained." Later Mr. Hotson was taken aside and told that his "attitude" was disrupting the class, and that further, with his "attitude," there was no chance in hell of his completing a graduate program in physics, so "save your money." He ended up at the Sorbonne studying French literature, and later became a professional land surveyor.

However, he has retained a lifelong interest in the "awkward questions" of physics, and with Dirac's Equation has found some answers.

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netic field, the "photon," the "strong nuclear" force, the Ψ wave, inertia, and gravitation. It provides direct-contact physical models that agree with experiment, as opposed to the purely mathematical (and unworkable) models so much in vogue. The phase-entanglement feature of quantum mechanics, demonstrated by Bell's Inequality and the proofs thereof, requires that our reality be *non-local*. This seems to banish causality. However, Dirac's equation provides causal, direct contact models which are nonetheless non-local.

Great theorists from Bohr to Feynman have asserted that "no one understands quantum mechanics." The student is warned for the sake of her sanity not to try to understand "how it can be like that," but to take all its strangeness on faith (Feynman, 1985). Like the White Queen in Alice, quantum physicists must "believe six impossible things before breakfast." However, merely with the single assumption that the Dirac equation *means what it says*, these features are intuitively, understandably resolved: all the "strange" or "odd" features of quantum mechanics follow simply, logically, naturally, and necessarily.

Introduction

The principle criteria for a successful scientific theory would seem to be the following:

Criterion 1. Simplicity. It should embody as few "entities" as possible, preferably only one. (This is William of Ockham's test, known as "Ockham's Razor": "Multiplicity ought not to be posited without necessity.")

Criterion 2. It should have few, preferably no, adjustable parameters. (Also known as fudge factors.)

Criterion 3. It should be mathematically consistent.

Criterion 4. It should satisfy all of the known data, including data unexplained, anomalous, or dismissed as "coincidence" according to previous theories.

Criterion 5. It should obey causality: every effect should have a *proximate* cause, with no "action at a distance."

Criterion 6. It should be falsifiable, making testable predictions.

The first of these, Ockham's razor, can be used as a general test of the soundness of a theory, as the general trend of successful science is from disorder and complexity toward order and simplicity. Before the advent of modern chemistry, although matter was thought to consist of the four "elements" earth, air, fire, and water, these could combine in unlimited ways. Thus contemporary thought allowed for an infinite number of "entities" with no valid rules for their combinations.

By 1890 science had shown that all matter consists of ordered combinations of ninety-two "irreducible" elements, or atoms. The "gravitational field" was another entity, and Maxwell had unified electricity and magnetism, so the "electromagnetic field" was another. Therefore, by this time the progress of science had reduced this infinite number of entities to less than one hundred.

The discovery of radioactivity showed that these "elements" were not irreducible after all, and by 1932 after Chadwick's discovery of the neutron it was found that all stable matter consists of ordered and understood combinations of just *three* entities—electron, proton, and neutron. In addition to these there was Anderson's newly discovered positron, the photon which was now widely considered to be a particle, and the gravitational and electromagnetic fields. Thus in 1932 the number of entities recognized by science totaled no more than *seven*. The unifying progress of science had over time reduced the number of entities from infinity to less than one hundred to a mere *seven*. (The actual low water mark had been reached a decade or so earlier, before the discovery of the positron and the neutron. The neutron was then supposed to be an electron/proton fusion, and the photon wasn't yet considered a particle, so the entities then recognized by science totaled merely four.)

> William of Ockham's test would seem to indicate that science took a very wrong turn sometime around 1932.

So far so good. It seemed obvious that this process of unification would continue, and reduce the number of entities still further. Great scientists such as Einstein dedicated their entire lives to unification. Nonetheless around that time the simplifying trend reversed, and by the end of the century, the accepted Standard Model (SM) of particle physics called for around thirty-six "fundamental" particles, most with an antiparticle, and each with its very own "field": again almost one hundred separate entities. *What happened?* William of Ockham's test would seem to indicate that science took a very wrong turn sometime around 1932.

Well, perhaps the universe doesn't shave with Ockham's razor—maybe it really *is* that complicated. But the evidence points the other way. The universe exhibits very conspicuous economy, even parsimony, of means. The DNA molecule, the basis of life, is arguably the most complex entity known. Yet its code is written using just *four* components, the four bases whose combinations comprise the genetic code. It can be shown by complexity theory that *three* bases would not provide sufficient complexity for this code, and five would be redundant. Yet *any number* of components *could have* been used. However, only four are necessary, only four are used. Further, all stable matter, including all of the chemical elements and their compounds such as DNA, is built of just *three* components—electron, proton, and neutron. Again only *three* components are necessary, only three are used. Consider this as a sequence, from more complex to less complex: *four* components are both necessary and sufficient to build DNA, *three* components are both necessary and sufficient to build all stable matter. Does this suggest that to build these *three* components would require *thirty-six* "fundamental" components, and nearly one hundred entities? Surely not.

Going by the above sequence, we should instead consider how many components are *necessary* to build electron, proton, and neutron. And here the computer shows the way.

Computer science shows that operations of unlimited complexity can be built up from just two binary components, yes/no, on/off, plus/minus. Since two binary components are all that is *necessary*, by Ockham's razor and the universe's demonstrated parsimony, two binary components should be *sufficient*. This is not to suggest that the universe "is" a computer (although several respected scientists, such as David

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The problem with the medieval debate over how many angels could dance on the head of a pin was that angels were unobserved entities, and so could have any desired properties. Each of these classes of unobserved entities in the SM amounts to a fudge or patch applied to save a failing theory. So long as these fudged entities are made unobservable *in principle*, like the angel or the quark, they are safe from experimental falsification.

Deutsch [1997] think it is), merely that computer logic and the logic of building a universe appear, necessarily, to be parallel.

As an exercise, consider for a moment in broad terms how a computer of unlimited capacity might go about modeling the physical universe, using merely its two entities. The ultimate aim must be the unlimited complexity and flexibility of the unlimited numbers of chemical compounds. But *the first thing a binary computer must do is construct the three*. Three is the builder. A triangle is the simplest figure to enclose space, a stool needs three legs, a universe needs three dimensions. And all stable matter requires just *three* entities.

Let's suppose that the computer, constrained by the universe's physical laws, manages to model the electron, proton, and neutron using just its two entities, which is certainly possible, as we will later show. Then, again constrained by physical laws, the only physically possible combinations of these three entities result in ninety-two "natural elements," most of them stable. (Note that *all possible* combinations are *actually* used.) And the possible (chemical) combinations of these ninety-two "elements" are unlimited. So the numbers of entities in the computer modeling sequence would be 2, 3, 92, unlimited.

This is the fastest physically possible route to unlimited complexity. It is faster than any arithmetic or geometric progression. These are the *necessary* numbers of entities; they should be *sufficient*. It is totally absurd to suppose that the sequence would go 36, 3, 92, unlimited, as the Standard Model (SM) insists.

By William of Ockham's test, therefore, the SM is far off track. How does it fare judged by the other above criteria? Even worse.

In contrast to the ideal of *no* adjustable parameters (Criterion 2), the SM requires at least *nineteen* adjustable parameters, values which have to be entered by hand. Since it can be proven that 2 + 2 = 3 with just *one* adjustable parameter, this would seem to be a major defect.

Further, the SM is not mathematically consistent (Criterion 3). The SM calculations of many ordinary values, such as the rest mass of the electron, come out to be infinite. However, from experiment we know the electron's rest mass to be 0.511 MeV. To get rid of this "impossible" result, "renormalization" is invoked: the positive infinity is, in effect, divided by a negative infinity. Since the result of this mathematically forbidden procedure is indeterminate, the desired value of 0.511 MeV is then simply entered by hand. This admitted fudge would not work if we didn't already know the answers.

Feynman, who originated the "renormalization" process (with Schwinger and Tomonaga), himself called it a ". . .shell game. . .Having to resort to such hocus-pocus has prevented us from proving that the theory of quantum electrodynamics is mathematically self-consistent. . .[renormalization] is what I would call a dippy process!" (Feynman, 1985) Asked for what he had won the Nobel Prize, Feynman replied, "For sweeping them [the infinities] under the rug." (Gleick, 1992)

On the face of it, if the results of calculations of ordinary values come out to be infinite, in case after case, shouldn't we take this as a gentle hint that something basic must be wrong, and start looking for a better model? Instead, like the freshman that looks up the correct values in the back of the book, we fudge the answers. A student who pulled such a stunt would flunk. The three famous professors who pulled it shared a Nobel Prize.

This grant of a Nobel Prize for what is, after all, nothing but an elaborate fudge, testifies to the malaise of current theory. This incredible award legitimized the fudge, which as a result is now an accepted, even rewarded scientific procedure. With this, physics lost the ability to self-correct, as a fudge can always be concocted to bring any datum, however discordant, into at least apparent accord with the current paradigm. As a direct consequence, *most* of the nearly one hundred entities required by the SM are *unobserved*. The problem with the medieval debate over how many angels could dance on the head of a pin was that angels were unobserved entities, and so could have any desired properties. Each of these classes of unobserved entities in the SM amounts to a fudge or patch applied to save a failing theory. So long as these fudged entities are made unobservable *in principle*, like the angel or the quark, they are safe from experimental falsification.

The SM also has a major problem with *mass*. Gordon Kane (1995) argues that the Standard Model should really be called the "Standard Theory" because it is *nearly* perfect—just a few minor flaws. He then goes on to mention one of them (p. 117):

> In its basic form, the Standard Theory is a theory for massless particles. All the leptons, quarks, and bosons must be particles without mass, or the mathematical consistency of the theory is destroyed. The photon and the gluons indeed have no mass, but the others do. Why not just insert a mass for them in the equations? Unfortunately, in a quantum theory all aspects of physics are so highly interconnected that if the masses are just put in, then calculations start to give infinite values for many ordinary measurements. (In the language of the last section of Chapter 4, the theory is then not renormalizable.)

In other words, the Standard Theory is a beautiful theory—but it applies to *some other universe*, one in which all particles oblige the theorists by being massless. Unfortunately, in *our* universe, the stubborn particles perversely persist in having mass, while stubborn theorists persist in clinging to

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It is an axiom of science that *no* theory will remain valid forever. That being so, the "current paradigm" is by definition *invalid*! "Defense of the paradigm" is therefore indefensible. Each new datum should be cause for a review, not just of the current paradigm, but of every choice that led up to it.

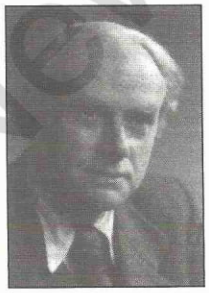
a theory that treats them as if they didn't. The current hope is that two more fudged entities, the (unobserved) Higgs field and its supposed quantum, the (unobserved) Higgs boson, will somehow solve this dilemma.

The remaining above criteria (4-6) are also violated by the SM, as will be shown in what follows. The roots of most of these violations go back to the early 1930s as well. The infinities that so plague the model, as we will demonstrate, also have their origin in the early 1930s, in an apparently wrong turn taken by science.

The Fork in the Road

By the above criteria, then, the SM would appear to fail in nearly every possible way, and all of its failures seem to stem from the early 1930s. By all indications science seems to have taken a wrong turn about this time. After three hundred years of progressively simplifying the description of the universe, with fewer entities and simpler laws, it suddenly turned the other way, with complexity and entities multiplying like rabbits. (Quantum Field Theory [QFT] in the SM is now so mathematically complex with its thirty-six or so [unobserved] fields that, as Treiman [2000] puts it, "There are no remotely realistic theories that are exactly soluble.")

Science frequently makes choices between alternatives. Once the choice is made, however, scientists tend to unify behind the accepted alternative to the extent of denying and eventually forgetting that there was any "real" choice made. Subsequent textbooks gloss over any possible alternatives, depicting science as a straightforward march up the one correct path toward truth. Since it is forgotten and denied that such choices existed, the results of these choices are rarely reviewed. Not only is there no provision, or incentive, for such a review, there is positive, and powerful, peer pressure against any such questioning of basic premises. (The inexcusable treatment of the astronomer Halton Arp [1998] is just one example.)


P.A.M. Dirac (1902-1984)

However, it is an axiom of science that *no* theory will remain valid forever. That being so, the "current paradigm" is by definition *invalid*! "Defense of the paradigm" is therefore indefensible. Each new datum should be cause for a review, not just of the current paradigm, but of every choice that led up to it. Let's suppose that, over the course of the history of science, ten paradigm-affecting choices are made. In each case, suppose that the rejected alternative has only one chance in three of being right. In each case, clearly science will choose the more probable outcome. Nonetheless, over the ten cases, the probabilities are over three to one that at least *one* of the ten rejected alternatives is correct, and that the adopted paradigm will be partially or completely wrong as a result.

Moreover, if the choice involves a paradigm change, the odds may be totally the other way, as it seems we will choose the alternative that defends the paradigm if that alternative has any plausible chance whatever of being right (Arp, 1998).

Many such choices were made in the early 1930s. Of course, in real cases the actual odds are difficult or impossible to assess. One choice in particular stands out, however, because of the passion aroused by the controversy, and because of its far-reaching effect on the shape of subsequent theory. This controversy involved the Dirac relativistic wave equation (Dirac, 1928a, 1928b), a relativistic generalization of the Schrödinger equation:

$$\sum_{\beta}\left[\sum_{\mu}(\gamma_\mu)_{\alpha\beta}\frac{\partial}{\partial x^\mu}+\frac{mc}{\hbar}\delta_{\alpha\beta}\right]\psi_\beta=0,$$
$$x^\mu=\vec{x},\ ict$$

Pais (1994) ranks this spectacularly successful equation ". . .among the highest achievements of twentieth-century science." It was the first to be Lorentz-invariant, it had electron spin as a necessary consequence, it gave the right magnetic moment, the Thomas factor appeared automatically, and the Sommerfeld fine structure formula was derived with the correct Goudsmit/Uhlenbeck quantum numbers. At low energies, the results of the ordinary Schrödinger wave equation are recovered. It predicted the positron, which was discovered by Anderson soon after. It has since become the very basis of Quantum Electrodynamics (QED) (Pais, 1994).

Despite these successes, the physics community greeted it with alarm and outrage. This was because the equation gave twice as many states as they thought it should have. They expected a Ψ with *two* components; but this equation gave *four*. After the discovery of the positron, it was realized that its *four* solutions call for electrons and positrons of positive energy, and electrons and positrons of negative energy (Pais, 1994).

As Dirac pointed out, this is because the energy-momentum-mass relation $E^2 = c^2p^2 + m^2c^4$, always associated with Einstein and Special Relativity has *two* roots; it calls for both positive and *negative* energy:

$$\pm E = (c^2p^2 + m^2c^4)^{1/2}$$

[The mass-energy relationship $E = mc^2$ was first derived and published by Oliver Heaviside (1890) and further refined by Poincare (1900), but Einstein (1905) first furnished the complete expression including momentum.] Dirac wondered what to do with the negative energy solutions. "One gets over the difficulty on the classical theory by arbitrarily excluding those solutions that have a negative *E*. One cannot do this in the quantum theory, since in general a perturbation will cause transitions from states with *E* positive to states with *E* negative." (Dirac, 1928a)

Since all negative-energy states have lower energy than any positive-energy state, Dirac wondered why there were *any* filled positive states, since according to Hamilton's law all entities tend to seek the lowest-energy state. He suggested

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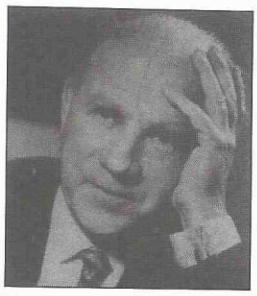
Werner Heisenberg (1901-1976)

that all of the negative energy states must be filled, like the filled electron shells in the Pauli exclusion scheme. Then, unless a "vacancy" occurred, positive energy particles would "float" on the surface of the negative-energy "sea" and stay positive.

Dirac's "sea" of filled negative energy states, while it satisfied the equation, didn't at all satisfy the physicists. Heisenberg (1928a) wrote to Pauli: "In order not to be forever irritated with Dirac I have done something else for a change." A little later he wrote, "The saddest chapter of modern physics is and remains the Dirac theory." He further added that Dirac's "magnetic electron had made Jordan melancholic." (Heisenberg, 1928b)

Later, after the discovery of the positron, again in a letter to Pauli, who had reported himself "Your (drowned in Dirac's formulae) W. Pauli," Heisenberg remarked, "I regard the Dirac theory. . .as learned trash which no one can take seriously." (Heisenberg, 1934a)

These emotional responses were not limited to Heisenberg, Pauli, and Jordan. They were general among the physics community. Their objection was not to the successful equation, but to its requirement of a sea of negative-energy states. They were all good Machians, insisting that theory should be based on observables alone. They were not at all open to a suggestion that they might have been missing half of reality all these centuries, as Mach had missed the atom. (Mach insisted to his death in 1916 that the atomic hypothesis "went beyond the data.") Heisenberg had developed the first successful version of quantum mechanics on a Machian basis, and an unobserved, ubiquitous "sea" was anathema.

Worse, it harked back to an old war, the "aether" conflict. On largely Machian grounds, Einstein in 1905 had declared the "luminiferous aether," the supposed carrier of light, to be unobserved, hence nonexistent. [Lorentz's electromagnetic aether (Lorentz, 1904, 1909) answered all of the other objections to a carrier of light, including the results of the Michelson-Morley experiment, so the only remaining objection was the Machian one.] For a generation, the "Aether War" had raged in every faculty. By 1930 the tide was definitely running with the Relativists, and most remaining aether enthusiasts were dying out. (Lorentz, their doyen, died in 1928.) They were far from forgotten, however. Any reference to a universal substance that undetectably filled space sounded too much like an aether.

The final argument was always that negative energy is impossible, with no imaginable physical meaning. Of course, pronouncements that something is impossible have a long history of looking foolish in retrospect, but this one seemed persuasive at the time, and is still heard. (We will later suggest a very possible physical meaning for negative energy.)

Heisenberg's "Window"

Heisenberg was the most upset by this theory, which outraged his Machian belief system, so it is no surprise that he was the first to work out a way to squirm out of the Dirac equation's and the energy equation's requirements of negative energy states (Heisenberg, 1934b).

He made use of one of Dirac's own suggestions. After absorbing extended criticism from the Machians, Dirac had concluded that, contrary to his earlier "hole" theory, *all* the negative-energy states must be filled with negative-energy electrons and positrons. He reasoned that if all the negative states and none of the positive states were filled, the two could have no effect on each other. Thus Dirac made what came to be called the "zeroth order subtraction," removing those parts of the theory which referred to the negative-energy "sea." (The subtraction utilizes a mathematical trick, the Grassman elements, to remove two of the states called for in the Dirac equation, the two negative energy solutions. The Grassman elements are generalizations of Hamilton's "quaternions," elements that satisfy such strange-looking equations as $a \times b = -b \times a$. Grassman's elements look even stranger. In them, $a \times a = 0$. They can be used mathematically to express the exclusion principle, but at the cost of eliminating negative energies. There is no justification for supposing they apply to Dirac's oscillators. Their use is equivalent to saying, "Let black equal white. Now, black doesn't exist!") While Dirac intended the step merely to simplify calculations, Heisenberg seized on it, using it to deny any existence to such states.

The problem was that such states seemed necessary, both to the theory and to the experimental evidence. Using the theory, Dirac (1930a), Oppenheimer (1930), and Heisenberg (1931) had all shown that every charged particle can give rise to unlimited numbers of electron-positron pairs and their associated photons, pulled up from the "sea" by the charge, making every interaction an infinite-body problem. Moreover, this "polarization of the vacuum," apparent in measurements even then, has since been rigorously verified (Pais, 1994). The Dirac theory (1934) required every charge to be surrounded by unlimited numbers of the opposite charged ends of electron-positron pairs (henceforth "epos"). Experiment verified that the epos were both present and necessary.

This "polarization of the vacuum" has since become QED's most celebrated success. Using difficult perturbation calculations involving the charges of an unlimited number of epos and their associated photons surrounding a charged particle, the theory computes the electron's magnetic "g" factor to an agreement with experiment of ten significant figures or more.

Along with the other Machians, Heisenberg had for six years been trying to find the "obvious" mistake in Dirac's "learned trash." He failed utterly: the equation was mathematically flawless, it was Lorentz invariant, it accounted for virtually everything concerning the electron and positron, and it was becoming increasingly useful. But it called for the unthinkable, the politically incorrect "sea" of negative-energy epos. So Heisenberg looked for and finally found what seemed to be an escape hatch. (Furry and Oppenheimer [1934] independently made similar suggestions.)

Since Dirac's "zeroth order subtraction" removes all trace of the negative-energy "sea" from the equations, Heisenberg (1934b) found that he could skirt around the "sea" (mathematically) as if it doesn't exist. The equations call for electron-positron pairs. But since the negative-energy "sea" removed from the equations now doesn't exist, they can't come from there. Therefore the operator that previously called for unlimited numbers of *negative energy* electron-positron pairs to be *raised in state* (from negative to positive energy), now *magically* became a "creation operator" of

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As Dirac noted, physicists had always arbitrarily ignored the negative energy solutions. If they were *real* in some sense, as Dirac's "learned trash" insisted, they had all been mortifyingly, catastrophically wrong all these years, ignoring exactly half of reality. And that other half of reality, alarmingly, seemed to resemble the anathematized *aether*.

unlimited numbers of *positive energy* electron-positron pairs. (*Magically* because they apparently appear from nowhere.) Since they come from nowhere, yet must be present, this operator creates them on the spot. Similarly, when they disappear again at this same sea level, they can't be returning to the non-existent "sea," they must be annihilating, so the state-lowering operator magically becomes an "annihilation operator." (See Pais [1994] for the details.)

In effect, Heisenberg merely put "horse blinders" on the equations, so they could no longer "see" the negative energy solutions. He reset his gauge to zero at "sea level." Using the "zeroth order subtraction," which forces all results to be positive, an "ocean" no longer exists: there are no negative solutions, so nothing is below "sea level." Those waves out there? Oh, they're just vacuum fluctuations around the zero baseline. We call them "Zero-Point Fluctuations." When a dolphin is ill-mannered enough to jump out of this non-existent ocean, we merely utilize the "creation" operator, and *voilà*, a dolphin appears. When it dives back into the non-existent ocean, quick, Henry, the "annihilation" operator, and presto! It's gone.

In defense of Heisenberg, the experimental evidence had indeed begun to look as if "creation" and "annihilation" were actually happening. In cloud chamber studies of cosmic rays, high-energy gamma rays (photons) suddenly gave birth to electron-positron pairs (epos), which separated at high velocity. The positron then would approach another electron, and the two would disappear, being replaced by high-energy (0.511 MeV) photons.

There was, however, one immense difference: Heisenberg's "creation operator" required the creation of unlimited numbers of electron-positron pairs (epos) *without any high-energy photons*, or, indeed, any measurable energy input at all. And when they are "annihilated" by the other operator, the epos vanish without a trace, producing no high-energy photons or any other detectable energy.

This massive violation of conservation bothered Heisenberg only momentarily, because there was a seeming "energy window" in the uncertainty relations that he himself had famously developed. These limited what one could know (measure) about a quantum state: if one measured the position of a particle exactly, then its momentum was maximally uncertain, and vice versa. He developed a similar expression for energy and time, namely that if ΔE and Δt are the respective latitudes in energy and time of observation, then $\Delta E \bullet \Delta t \geq h/2\pi$. He took this to mean that if one observed for a sufficiently brief interval of time, (Δt approaches 0), then the energy available would be effectively unlimited (ΔE approaches infinity).

He therefore decided that these "created" epos must be "virtual" rather than "actual" (though the equations suggest no such thing), coming into being (in unlimited numbers) for a brief instant of time using energy "borrowed" (in unlimited amounts) from this relation. And when they "annihilate," he argued, they merely "pay back the loan" to the uncertainty relation.

Operationally, of course, "virtual" here means "having whatever properties we chose." One of the handy properties chosen for these unlimited numbers of "virtual" epos is that, although formed of unlimited amounts of energy, they somehow don't gravitate. Thus they violate General Relativity, which states that such unlimited energy should curl the universe into a little ball. Every electron, surrounded by unlimited numbers of epos, should be a "black hole."

So stood the question in 1934. The Dirac equation was a direct threat to the reigning paradigm. As Dirac noted, physicists had always arbitrarily ignored the negative energy solutions. If they were *real* in some sense, as Dirac's "learned trash" insisted, they had all been mortifyingly, catastrophically wrong all these years, ignoring exactly half of reality. And that other half of reality, alarmingly, seemed to resemble the anathematized *aether*. Though his interpretation seemed to violate either conservation or General Relativity, or both, Heisenberg's mathematical conjuring trick offered an escape route, a window, however tiny and iffy. Perhaps the paradigm could yet be saved.

As we know, science took this escape route and never looked back. They saved the paradigm. But were they right to do so? Let's try to set up some kind of balance sheet.

At What Cost?

On one side we have perhaps the two most used and respected relations in modern physics, the energy equation and Dirac's relativistic wave equation. The energy equation calls for negative energy, and Dirac's equation specifically calls for negative-energy electrons and positrons in unlimited numbers. Experiment confirms that electron-positron pairs (epos) in unlimited numbers actually exist, surrounding and being polarized by every charged particle.

As noted above, the Dirac equation was spectacularly successful. Not only did it explain everything Dirac hoped it would, the above listed accomplishments include several complete surprises, as were the totally unanticipated predictions.

But if we follow Heisenberg, we are expected to believe that this colossus of equations has feet, or roots, of clay. We are told that it is completely wrong *only* in this one thing, the *sign* of the electron-positron pairs verified by experiment. They are not merely "raised in state" from a *negative energy* "sea" of such pairs. That, we are assured, is impossible: it must be "an accident of the formalism." Instead, these necessary epos must be *created on the spot* in an operation that violates either conservation or General Relativity or both.

Arthur C. Clarke pointed out that if a man in a long white coat tells you that something is possible, he is prob-

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Since there are *unlimited* numbers of epos around *every* charge at *all times*, it doesn't matter how briefly each individual epo exists, this amounts to a *permanent* loan of *infinite* energy. "Creation" is the proper term for it: only God could have that much energy to loan.

ably right. But if he tells you something is impossible, he is almost certainly wrong. Yet here we are told that something called for by *both* of these most respected of relations is impossible. There are about eight different things that the Dirac equation got exactly right, but this *one thing* it got wrong? Surely, if it is completely wrong on something so basic, it would have given wrong answers or fewer answers elsewhere as well. To be so certain it is wrong science, we must have *direct evidence* that negative energy doesn't exist, right?

Well, that's a problem—you can't prove a negative. There is no way to prove that negative energy won't someday be shown to be real, with a physical meaning. For the moment, let's leave the question hanging.

The Miracle of "Creation"

However, for Heisenberg to put physics into the "creation" business is something else entirely. In what form does a "relation" loan out "pure energy"? Cash, check, or money order? And since there are *unlimited* numbers of epos around *every* charge at *all times*, it doesn't matter how briefly each individual epo exists, this amounts to a *permanent* loan of *infinite* energy. "Creation" is the proper term for it: only God could have that much energy to loan.

There are further conservation problems with any "creation" process, even one where the mass-equivalent energy is supplied by real, 0.511 MeV photons. For both electron and positron have spin (angular momentum) energy equal to $\hbar/2$. By any assumption as to the size of electron and positron, this is much more energy than that supplied by photons at "creation," or taken away by photons at "annihilation." *Somehow the "created" electron has something like sixteen times more energy than the photon that "created" it.*

This spin energy is *real* energy. It is the angular momentum needed by the electron to set up a stable standing wave around the proton. Thus, it alone is directly responsible for the extension and stability of all matter. Ultimately, it supplies the $h\nu$ energy acquired by a photon when an electron jumps from one orbit to another. This half-integer energy is the cause of Fermi-Dirac statistics, of the Pauli exclusion principle, and ultimately of the periodic table of elements.

In mathematics, if you set two things spinning in opposite directions, and take the average, the spins average to zero. But in the physical world, giving two real objects large amounts of angular momentum takes real energy. Instead of honestly facing this gross abandonment of conservation, current theory dubs particle angular momentum an "intrinsic attribute." All that says is, "This energy is there; we don't know where it comes from, so let's not talk about it." Calling it an "intrinsic attribute" is supposed to close the subject, like the Stephen Leacock aphorism: "'Shut up,' he explained." Naming and agreeing to ignore it makes this 1600% violation of conservation go away. In effect, current theory proclaims a miracle every time "creation" or "annihilation" is invoked—perhaps 10^{100} or more times a second. This demonstrates that conservation is merely paid lip service in the present practice of physics—something to be respected if it agrees with the current paradigm, but thrown to the winds if it proves inconvenient.

Even ignoring these massive violations of conservation, it seems hopelessly naïve to suppose that complex entities such as electrons and positrons, with spin, charge, and a number of other properties, could be "created out of nothing" but "pure energy." This is like supposing that if we put a bunch of electronic components in a box, and shake them hard enough (*i.e.* add "pure energy") the result will be a computer. "Pure energy" can never supply the exact and specific *information* necessary to make the highly complex little entities that we call electron and positron. After all, *we* don't know how to make either electron or positron. What is "electric charge"? We haven't a clue. Why are their spins quantized in half-integer values? No idea. Where do they get their immense, anomalous angular momentum? Beats us. And how on earth do they manage to pack all this into a zero or near zero radius? Yet we baldly suppose that "pure energy" knows how to do all these things *we can't do*!

Given all these problems with Heisenberg's "window," wouldn't it have made sense to at least *look* at what two of the most successful equations in recent scientific history mandate? They say that electron-positron pairs already exist, everywhere. Instead of being "created" in pair production or around every ion, which as we have seen involves massive violations of conservation, they are merely *raised in state* from negative to positive energies.

We will later look at this question more closely, and show why this "raising in state" requires *no* additional energy, resulting merely from the ion's unbalanced charge. First we need to look at more problems with "annihilation."

When an electron approaches a positron, they don't just rush together and disappear. Instead, they approach until they are a distance apart that is the width of the electronic ground state of hydrogen. At this relatively large distance (some 56,000 times the diameter of a proton) they start to orbit around each other in the configuration called "positronium." (This in itself should have told us that something other than "annihilation" was going on.) They never get closer to each other than *atomic* distances. After orbiting each other in this pseudoatom for a time that depends on whether their spins are parallel or opposed, they emit two or more photons that total all of their positive energy. After that they are no longer detectable, and conventional wisdom says that their charges and spins have "cancelled" and that they have "annihilated" and are no more. But since they never get closer to each other than 56,000 times the diameter of a proton, how can they possibly "cancel and annihilate"? They never get anywhere near each other, and nothing passes between them. For them to "annihilate" would be *action at a distance*, a direct violation of causality. Doesn't it make more sense to sup-

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pose that they still exist, as the Dirac equation requires, merely lowered in state to negative energies?

Another problem: to say that something has *charge* means that it has *potential energy* with respect to every other charged particle in the universe, and vice versa. For an electron and positron to "annihilate" while they are a large distance apart means that, according to Maxwell's equations, the potential energies of every charged particle in the universe must change *instantaneously*, except for those that are exactly equidistant from both of them. This violates conservation not only locally, but universally. It is *real* action at a distance, violating causality as well. But again the problem would seem to be solved merely by taking seriously what the Dirac equation says: that the spins and charges still exist, merely lowered in state to negative energies.

What the equations call for validates the conservation of charge, which is violated by "creation" and "annihilation." Just as conservation of mass-energy means that mass-energy can neither be created nor destroyed, so conservation of charge means that charge can neither be created nor destroyed. (We will later look at other supposed creations of charge, such as beta decay, and show that in each case the supposed creation was merely the separation of an existing epo.)

Arp's Axiom

So we see the choice that scientists of the time had to make: whether to believe what these fabulously successful equations say about negative energy, and try to figure out what negative energy might mean, or to escape through Heisenberg's "window" and save the paradigm. As we know, they saved the paradigm, even though this required wholesale miracles that put science into the "creation" business on a scale rivaling the God of religion. Almost incidentally, it required immense violations of causality, of conservation of charge, and of conservation of angular momentum, as well as the mind-numbing violation of conservation of mass/energy. Thus it violated four of science's most basic "laws." One wonders if there are any lengths to which scientists will *not* go in order to save the paradigm. In this case, saving the paradigm would seem to involve the virtual abandonment of science itself.

In this, they obeyed what we might call "Arp's Axiom." The astronomer Halton Arp (1998) noted that when faced with a choice involving a paradigm change, scientists will almost invariably choose the alternative that will save the paradigm, regardless of the evidence. ["Can we count on conventional science *always* choosing the incorrect alternative between two possibilities? I would vote yes, because the important problems usually require a change in paradigm which is forbidden to conventional science," Arp, 1998.] Yet in this case, the odds that they made the wrong choice would seem almost incalculably high. Surely they were high enough that *someone*, in the time this question was being debated, would at least have suggested examining the ramifications of the other choice: of the negative energy electron-positron "sea." At the least someone might have suggested that the choice be held in abeyance until more evidence was in.

But neither of these appear to have been suggested; if they were suggested, they were certainly not done. [H. Bondi (1957) appears to be an exception. Much later, he examined negative energy within General Relativity. Also, T.E. Phipps, Jr. (1976, 1986) explores both negative energy (the "hole theory") and negative (or "imaginary") momentum in his "Beta Structure Hypothesis."] The case seems to have been decided with apparent unanimity soon after Heisenberg's "window" became widely known. (That Furry and Oppenheimer [1934] independently made similar suggestions of course would seem to strengthen Heisenberg's case.) Even Dirac appears not to have pursued negative energy much farther. His objections to QED were on the grounds of infinities (Pais, 1994).

Would the decision have changed, had the question been held in abeyance? To consider this, we have to look at the results of this choice, immediate and longer-ranged.

The first result was highly questionable by William of Ockham's test. Heisenberg introduced four new (unobserved) entities, bringing the total number of entities instantly from seven to eleven. (The virtual electron, the virtual positron, the virtual photon, and a "relation" gone into the loan business, with infinite energy to loan out.) This was a considerable abandonment of his Machian principles. And as we know, entities have proliferated without limit ever since.

Furthermore, almost immediately the theory was engulfed in infinities. For, of course, if these epos are "created" by the electron's charge, its mass must include them—an infinite-body problem, making the mass of the electron, as Treiman (2000) puts it, "slightly infinite." Moreover, surrounded by this infinity of positive charges, its "bare" charge had to be infinite also, or no charge would "leak out" to be measured. And virtually any electromagnetic process one could name turned out to be infinitely probable.

These infinities continued to plague the theory, turning up in endless additional cases and making life miserable for everyone until, in exasperation, we fudged the answers we wanted. This only swept under the rug certain classes of infinities, but at least it allowed us to do the theory and extract additional information after some of the infinities were wished away.

After the Nobel Committee had dignified this fudge with a prize, there was no longer any need to consider changing the paradigm when conflicting data threatened it. Following Heisenberg's lead, one merely crafted unobservable entities with suitably designed properties that made it all right again.

"But wait," the defenders of the paradigm exclaim. "The electron's magnetic 'g' factor agrees with experiment to better than ten significant figures. This proves that we made the right choice!" Sorry, it doesn't. The Dirac theory also calls for positive-energy epos to surround every charge. (Moreover, as Dirac pointed out, a perturbation such as this will cause transitions from states with E positive to states with E negative.) So this one calculation would be exactly the same, whichever choice was made. But seemingly all of the other calcula-

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> With new discoveries being made almost daily, no theory can be expected to be the final answer. In all probability, there *is* no "final answer

tions come up either infinite, or so imprecise as to call into question the validity of the theory. An example is the magnetic moment of the proton, in which the measured value is 10,000 times more accurate than the theoretical value (Feynman, 1985). Obviously, this is why we hear only about this measurement of the "g" factor, the one total success, not about the numerous total failures and near misses.

Therefore it would seem that the accepted paradigm's *only* instance in which near-perfect agreement is reached between theory and experiment is the *one* instance in which both choices would give the same result.

It is increasingly clear that we made a choice to save the existing paradigm despite the basic laws of physics, the evidence, and the clear meaning of the equations. As a direct result, violations of conservation, entities, infinities, and ever more mathematically intractable theories proliferated without limit, right up to the present. But there is one recent development that calls into question the very basis of that choice.

The Smoking Gun

It turns out that, in effect, the equations of QM act as if *time* is quantized. As Prof. Treiman (2000) explains, "There is another inequality relation in quantum mechanics that is often cited, one involving energy and time. It has the look of an uncertainty principle but it stands on a different footing than the Heisenberg uncertainty relations discussed above." He goes on to show that there is a minimum time, τ, which must elapse before the wave function "changes appreciably." [This minimum time appears to be $2e^2/3mc^3$, or 6.26×10^{-24} seconds. We will discuss this later.] This means that the wave function changes only in increments of the constant τ. From the time $t = 0$ to $t = \tau$ there is no change in the function; then at $t = \tau$, all the change happens at once. He then shows that the modern version of what Heisenberg assumed to be the uncertainty relation $\Delta t \bullet \Delta E \geq \hbar$ is really the inequality $\tau \bullet \Delta E \geq \hbar$. (We will examine this apparent quantization of time in more detail later.)

If time is a constant that can only come in increments of τ, as this inequality relation shows, then obviously it can *not* be taken in increments approaching zero. Furthermore, in a "perfect quantum measurement" situation (such as the Airy pattern) (Herbert, 1986) the root mean square energy deviation would *equal* $\hbar/\tau$. At most it would be a random amount over this, depending on the measurement situation. Therefore Heisenberg's "relation" is a *poor* "relation": it does *not* have infinite amounts of energy to lend on every occasion. In a good measurement situation all the energy available is $\hbar/\tau$. There certainly is none to spare to "create" infinite numbers of electron-positron pairs.

This means that Heisenberg's window never existed.

To recap: Heisenberg's *window* was not outrageously in violation of conservation only because Heisenberg's *relation* was supposed to supply infinite amounts of energy to every interaction. If that is not the case, as the above "smoking gun" emphatically shows, then Heisenberg's window doesn't exist.

But the paradigm escaped through that nonexistent window.

Negative Energy

It seems we need to go back to 1934 and take another look at Dirac's negative energy solutions. As mentioned above, simply taking these equations at their word eliminates most of these infinities and gross violations of conservation. The equations say that unlimited numbers of epos already exist, everywhere, and that they are merely *raised in state*, not "created." It is possible, perhaps, that there exists another "window." Certainly defenders of the paradigm will search for one. However, Heisenberg (and other brilliant theorists, such as Pauli, Jordan, Furry, and Oppenheimer) searched for six years, then came up with a window that wasn't. In any case, the above difficulties with the present paradigm indicate very clearly that there were immense problems with the choice they made.

What might we expect to find down the "road not taken"? As noted in the opening argument, Ockham's razor measures the progress of science in terms of simplicity. If "negative energy" is a correct road, we would expect the number of entities recognized by science, seven in 1932, to decrease further rather than to increase to nearly one hundred, as they have done since then. We would expect a consequent simplification of the mathematics involved. We would certainly expect to clear up the gross violations of conservation implicit in Heisenberg's "creation" window. And this would, as we will show, clear up the infinities that plague current theory without recourse to fudging.

This is such an ambitious project that we cannot hope to prove all of this in the present work. We merely hope to indicate the directions that future theory might take in following the clear leads of the energy equation and, most particularly, of the complete Dirac equation in the light of subsequent discoveries. And above all we should remain *flexible*. Clearly, this crisis at the heart of science was the result of a chronic "hardening of the paradigm." With new discoveries being made almost daily, no theory can be expected to be the final answer. In all probability, there *is* no "final answer."

Therefore, while we may present a number of probable consequences of following this new road, keep in mind that they are all tentative, subject to revision as well as analytical and experimental falsification. In view of this, the first step is to take a long look at the rejected alternative, the negative energy sea that this most successful of equations calls for. In particular, what could "negative energy" represent?

Symmetry

These two equations call for symmetry between positive and negative energy. This only matches the symmetry between the forces recognized by physics. There are two kinds of forces in nature, those that bind matter together, and those that free it, that blast it apart. The binding forces, such as gravitation, the "strong nuclear" force, and the Coulomb force between unlike charges, all have negative signs. The freeing forces, such as the repulsive Coulomb force between like charges, have positive signs. The positive-sign forces act to increase the amount of positive energy; the negative-sign forces all act to decrease it. Logic would indicate that "positive energy" would be the result of positive forces, and "negative energy" the result of negative forces. However, because

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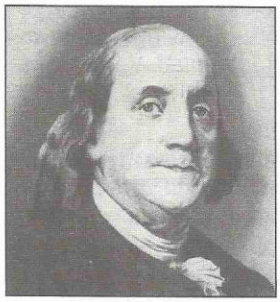

Benjamin Franklin (1706-1790)

matter (mass) is positive energy, our reality has a large positive-energy balance. It never seems to venture into negative territory, so we get by with an illogical "single-entry" bookkeeping that treats positive energy as the only kind.

The blame for this appears to fall on Ben Franklin, who flipped a coin and chose to designate static electricity with a deficiency of electrons "positive" and that with a surplus of electrons "negative." He assumed correctly that there was a "unit of electricity," that electricity was the transfer, the flow of some charged entity; but he guessed exactly wrong as to which one. By this mischance the electron, the very unit of electricity, was saddled with a minus sign. But this mistake had far reaching consequences. Had he guessed correctly as to *what was flowing*, both the electron and what we now call "negative energy" would have had a *positive* sign. In this much more logical case, would we have been so certain that something called "negative energy" is the *only kind*, and that something we would have to call "positive energy" *doesn't exist*? Would we have been so quick to say that "positive energy" is *impossible*?

All through science, we observe almost total symmetry between positive and negative. Charges come in positive and negative, forces come in positive and negative, particles are symmetric between matter and antimatter. This last came as a great shock to physicists in the 1930s, but after it was accepted, symmetry became the justification for many of our theoretical structures. Only in energy do we deny that such a symmetry exists. This prejudice would seem to have its roots in the past, in a time when most scientists were profoundly religious. To them, "negative energy" perhaps sounded like something invoked by someone calling on Powers of Darkness, and they were only too glad to ignore it and deny its existence. But surely it is time to rise above such superstition, especially when we realize that, but for Franklin's mistake, "negative energy" would be "positive energy."

Surely the forces that combine, that draw things together, that build, in all propriety should be considered *positive* forces. Yet Ben's mistake saddles them with a minus sign. And just as surely, the forces that force apart, that break down, that explode, we would normally call *negative* forces. Had Franklin made the right choice, this illogic would be cured. But mark the sequel: our reality then would have been seen to have a large *negative energy* balance.

In this case, since both the energy equation and Dirac's equation are *symmetric* with respect to positive and negative energy, surely someone would have postulated a symmetrical reality somewhere with a balancing *positive energy* surplus. The solutions to Dirac's equation amount to a *matter field* containing unlimited, symmetrical amounts of negative and positive energy. This implies that there exists a symmetrical "sea" with a surplus of energy opposite in sign to that of our matter/energy. This would restore the symmetry between negative and positive energy called for by these successful equations.

This will require a change of focus, especially for physicists who have worked with the "single-entry" bookkeeping for so long. However, a more logical "double-entry" system works equally well with everyday energy issues, and it clears up places where the "single-entry" system has problems, such as near absolute zero. Just as an exercise, try to think of "positive energy" as the result of positive forces, and "negative energy" as the result of negative forces. Then, in the "lowering in state" called for by Dirac's equation, when all positive energy is removed from an electron and positron and they drop into the "sea," the only force between them is the negative Coulomb force, and they clearly would have only "negative energy." And since they are then apparently undetectable, it would seem that "negative energy" doesn't gravitate or have inertia. ("Mass" is only the result of *positive* energy.) We will discuss the reason for this in what follows.

There are other clear indications that negative energy *does* exist, but has merely been mislabeled. According to Feynman's "parton" model, the nucleon consists of a swarm of charged particles which are held together by the "strong nuclear force," which is *negative* in sign. As many of these partons have like charges, these are strong *positive energy* forces trying to blast the nucleon apart, which must be balanced by the even stronger *negative* strong nuclear force. To avoid calling the results of this force "negative energy" is a purely semantic prejudice. To be stable, the nucleon must be a balance of negative and positive forces, hence negative and positive energies.

The measured mass of an alpha particle is substantially *less* than the sum of the mass-energies of the two neutrons and two protons that make it up. To avoid the proscribed term "negative energy," this difference is called the "mass deficit" or the "binding energy" or "negative *potential* energy." ("Potential energy," in general, is a euphemism for the dirty term "negative energy," used when the energy supplied by a negative force such as gravitation is unavoidable.) But each nucleon still has its like "parton" charges, so when you add the two protons, the "bound" nucleus must have *more* (positive) energy than its "unbound" constituents. (The positive Coulomb repulsion between the two protons in these close quarters is enormous.)

The only way in which a "bound" nucleus with more *total* energy can have less *positive* energy is if this "binding energy" is *negative* energy. (Its sign of course is negative, as is the sign of the strong nuclear force that binds the nucleus together.) Since the strong nuclear force is *negative* in sign, and since the "binding energy" that results from it is *negative* in sign, it seems clearly doubletalk to say that negative energy doesn't exist.

When two additional positive charges are added in the formation of an alpha particle, all of the parton charges are still there. Thus, the particle has *more* blasting-apart (positive) energy, and by conventional thinking should mass *more*. However, to be stable, the negative energy-positive energy balance must change. So the alpha particle as it forms divests itself of some positive energy, the energy that powers the sun, thus giving the particle a higher percentage of (non-gravitating) binding negative energy, and making it stable again in spite of the additional two positive charges.

Negative Roots

Science has ignored the negative energy solutions to these equations as "imaginary," like the square root of a negative number. However, the square root of minus one is not "imaginary"—that is perhaps an unfortunate name. Mathematically, represented as *i*, it simply designates a number field, or dimension, at right angles to the everyday three. It is necessary to many disciplines, especially electronics. In the Einstein-Minkowski interpretation of special relativity this "imaginary"

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dimension is *time*. According to Minkowski (1909), there is "no difference" between *x*, *y*, *z*, and *ict*, where *t* is time and *c* is the velocity of light. Everyone who takes relativity seriously, therefore, believes in the reality of at least *one* direction in which one cannot point: a definitely non-Machian belief. However, mathematically there is no limit to the number of dimensions. In electronics, for instance, this "imaginary" dimension is *not* time. So it would seem that we need at least *five* dimensions.

Many of the popular string and superstring theories require, for symmetry, a space of ten dimensions (Sirag, 2000). General Relativity as well calls for ten tensors, or "dimensions of curvature" (Sirag, 1977a). To quote Dirac, (1963), commenting on the ten tensors of curvature of General Relativity, "The gravitational field is a tensor field with ten components. One finds that six of the components are adequate for describing everything of physical importance and the other four can be dropped out of the equation. One cannot, however, pick out the six important components from the complete set of ten in a way that does not destroy the four-dimensional symmetry." Recent studies in astronomy have shown that space on a large scale is *not* curved, but appears to be Euclidean to the limits of measurement (Arp 1998, Van Flandern 1998). In this case, General Relativity's ten tensors of curvature become merely linear *degrees of freedom*, or dimensions.

Dirac (1928a, b) laid the foundations of QED with his relativistic wave equation. In doing so, though, Dirac found that having three dimensions "real" and the fourth "imaginary" didn't work—it violated the symmetry. He took the first derivatives of all four dimensions by introducing *i* as well into *x*, *y*, and *z*, making them symmetrical by making them *all* "imaginary." Most physicists have considered this a trick, an "accident of the formalism," and disregarded it. However, when added to Dirac's above statement about the six "necessary" (dimensional) components and the four "unnecessary" ones, this might imply that our entire reality is "imaginary," as eastern mystics have insisted for thousands of years.

All it need mean, though, is that there exist six *other* dimensions that are in "imaginary" (orthogonal) directions with respect to our four, while our four are similarly "imaginary" with respect to the other six. This gives us a place to put Dirac's negative-energy "sea." As we will demonstrate, it also gives us a physical explanation of "negative energy."

The Kinetic Theory of Mass/Energy

What is mass? Recent thought suggests that the energy equation, instead of saying that two different things can somehow be converted into each other, really means that mass is just another form of energy (Haisch and Rueda, 1997). At a fundamental level, all matter consists of charged particles in harmonic motion (*Cf.* Feynman's "parton" model of the proton/neutron). Mass appears to be the harmonic motion of charged particles "trapped" within an energy well of some kind. This is why the most convenient and most often used unit expresses mass in terms of energy: the eV.

What then is this stuff, energy? As mentioned above, the SM has no idea what mass is. But as just another form of energy, it appears to be firmly associated with motion: the harmonic vibration of a charge, or linear motion (momentum). Many of the recent theories in Stochastic Electrodynamics (SED) use this kinetic definition (Puthoff, 1989) which is of a piece with the general kinetic definition of mass in the Lorentz relationships (Huang, 1952). According to Haisch, Rueda, and Puthoff (1994), mass is caused by an action of the Zero-Point Fluctuations (ZPF) of the vacuum electromagnetic field that resists the acceleration of a harmonically vibrating charge. "Mass is the manifestation of energy in the ZPF acting upon [vibrating] charged particles to create forces." (Haisch and Rueda, 1997)

By this kinetic definition, an electron-positron pair vibrating in a direction at right angles to our ordinary four, an *"imaginary"* direction, would have *negative energy*, the negative root of the Dirac equation. *Just as the square root of a negative number merely refers the result to a direction at right angles to our ordinary directions, so the negative root of the energy equation refers to an energy (a vibration of charges) in one of these "imaginary" directions.*

All of the groundbreaking equations of quantum mechanics contain *i* either explicitly or implicitly. The meaning of this has been staring us in the face for seventy years. *These "complex" functions involve vibrations partly in "real" partly in "imaginary" directions.* (And some that are "pure imaginary," such as the $\pm c$ velocity eigenvalue of the electron/positron.) We have been like Mr. A. Square from Flatland witnessing the intrusion of a three-dimensional creature into his two-dimensional domain, puzzled over such seemingly impossible events, but unable to comprehend "how it can be like that." Clearly, in both his case and ours, reality comprises more dimensions than those we can directly sense.

And most conclusively, a perturbation, as Dirac pointed out, must cause transitions from states of positive energy to those of negative energy. Quantum mechanics *must* be symmetric with respect to energy. Since our reality has a large positive energy balance, symmetry requires another reality with a large negative-energy balance. Vibrations of epos in these "imaginary" directions, as called for by the energy equation and Dirac's equation, would seem to meet this requirement.

This would also seem to explain the relative unobservability of this negative-energy domain. It has no inertia, hence no "mass," for reasons we will examine later. This, of course, will explain why "binding energy," above, has no inertial or gravitational mass.

Since these equations call for negative energy solutions, and since there is in fact a physically possible explanation for negative energy, there seems to be no further excuse for doubting that *all four* of the Dirac equation's roots have physical meaning.

The Electron-Positron Pair

The negative-energy electrons and positrons called for, however, appear to be permanently associated in pairs—epos. What can this mean? In our experience, an electron and a positron form "positronium," then lose all their positive energy and become undetectable. According to Dirac's equation, they drop into the negative energy sea. What configuration do they assume there? For a possible answer, we need to consider what Dirac's equation says about the electron.

Dirac's equation describes a "spinor field." In such a field, rotation of the wave function through 360° does not get it back to its original state, but to its opposite: the electron has to "turn around twice" to get back to where it was. At 360°, its wave function Ψ becomes $-\Psi$ and it becomes, in effect, a positron travelling backwards, to arrive at 0° and switch back to an electron. (In QED, a positron is considered to be an

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electron travelling backwards in time [Feynman, 1985].) So a positron is really only a totally out-of-phase electron.

However, the equation also says (Huang, 1952) that the electron always travels at velocity c: its velocity eigenvalue is $\pm c$. Thus, in addition to whatever overall (macrocosmic) motion the electron has, which we could call its momentum, the electron has an internal vibration at velocity $\pm c$. Doesn't this mean that this internal vibration is as an *electromagnetic wave*? That's the only momentum-carrying entity allowed to travel at c. Furthermore, this internal vibration *must* be in an "imaginary" direction, or, combined with its "momentum" velocity, it would at times exceed c, which is not allowed in "real" directions for a "positive energy" particle. (This is the first *explanation* ever given for this eigenvalue vibration that doesn't violate the Lorentz relationship.)

The only way it could travel at c and not at any other velocity would be for the electron's wave (Ψ) to be *reflected* at 360 degrees by the spinor "phase change" (positive to negative), thus changing electron to positron. (Since in this state they have no "mass" or inertia, this reflection takes no time or energy.) The analog would be a vibration traveling along a string fixed at each end, therefore reflected at each end. A spin $^1/_2$ particle is out of phase with this phase change, and so is reflected. A spin 1 particle merely gets sent on its way, this being the fundamental difference between fermion and boson. This accounts for the fact that the fermion's wave doesn't spread. (The Fourier sums of waves that have amplitude only in a small area ["wave packets"] show that a non-spreading wave is possible, but don't explain *why this should happen*. Moreover, they *do* spread with time, as required by the uncertainty relationship. Also, the waves are still *present* even in areas where they add to 0 amplitude.)

This gives a possible model for a non-annihilating, non-spreading electron-positron pair. For one thing, they are both fermions, so the probability of them being in the same place at the same time is exactly zero. (Another reason they can't "annihilate.") Therefore they must establish some stable relationship at a non-zero distance from each other. However, according to the above reciprocation, an electron and a positron could share a very stable relationship, vibrating in an imaginary direction while turning into each other every 360˚. On this model, they would be "particles" only at 0˚, 360˚, and 720˚, turning into waves in between ("wave-particle duality"). And if they traveled as electromagnetic waves, they would not interfere with each other as they passed. Since in the least-energy arrangement their spins and charges would cancel, the epo would appear to all the universe (and to the equations) as a neutral spin-zero boson, vibrating in an "imaginary" direction. (According to the kinetic theory, only charged entities can have energy, so any neutral spin-zero boson would have to be an association of entities whose spins and charges cancelled.)

Moreover, the *period* of this reciprocation would have to be the "quantum of time," τ, equal to $2e^2/3mc^3$, or 6.26×10^{-24} seconds. As shown above, this is the time required for an "appreciable change" in the wave equation, which therefore only changes in increments of τ. This is Γ_e, the Lorentz-Abraham damping constant of the electron, and in classical electrodynamics, it is called the "damping constant" (Jackson, 1975) or the "characteristic time" (Jackson, 1993) of the electron. In particle physics, this is the minimum time taken by any interaction, and interactions that take longer than this seem to require exact multiples of this "quantum of time." Since they travel at c as electromagnetic waves, this would make the "length" of an epo (a one-dimensional string, with a "point particle" at each end) equal to τc, $2e^2/3mc^2$, or 1.87×10^{-15} meters. This is the measured diameter of the proton, which, as we will see, is *not* a "mere coincidence."

"Pair Production"

We can now consider the interaction miscalled "creation." A high-energy photon collides with something, say a lead nucleus, and produces a "pair"—a "real" electron and positron, which separate at high velocity. Using the "complete" Dirac theory, we would regard this as the capture by a (negative energy) epo of sufficient positive energy to split the epo in half, and to give each half 0.511 MeV of "positive" energy plus sufficient momentum to escape their mutual Coulomb attraction. They each now have a positive energy of m_ec^2 plus momentum energy, pc, in a "real" direction.

However, the electron, as part of a negative-energy epo, has a one-dimensional oscillation at $\pm c$ in an "imaginary" direction. It retains this oscillation as a "real" electron—hence its velocity eigenvalue of $\pm c$ (Huang, 1952). (Since this one-dimensional oscillation has no "mass" or inertia, it can't be affected by the capture, and the electron, obeying conservation of angular momentum, retains it.) Therefore the "real" electron's wave function has a circular vibration at c in two "real" directions (giving it mc^2 of positive energy) plus a vibration at $\pm c$ in an "imaginary" direction, which adds no positive energy. This makes its total (spherical) vibration *complex*—part "real" and part "imaginary." However, a component of the *angular momentum* of its "imaginary" spin carries over, giving the "real" electron its immense angular momentum of $\hbar/2$. Note that if all three vibrations were all positive energy, the electron's energy would have been mc^3, around 1.5×10^8 MeV. As it is, because of our four "real" dimensions, the component of this complex spin energy in any "real" direction appears to be $4^2(mc^2)$ or around 16 times the electron's positive rest energy.

This also accounts for the fact that this quantum number is two-valued—"spin up" or "spin down," as any "real" direction can only be at right angles to three "imaginary" directions at a time. And it of course accounts for the fact that the electron's wave function is a *complex* variable, with "real" and "imaginary" parts.

This further accounts for the hitherto mysterious fact that the electron's angular momentum is also complex, as the electron's angular momentum vector can not point in any "real" direction. Consequently, neither can the electron's orbital angular momentum vector in an atom (Treiman, 2000).

With this understanding, we have at a stroke eliminated the massive violation of energy and angular momentum conservation involved in "creation. The $\hbar/2$ angular momentum of the electron is compounded from the epo's vibration at $\pm c$ in an "imaginary" direction in the negative energy sea, and returns to that sea when it meets a matching positron. This understanding also eliminates the violation of conservation of charge, as well as the violation of energy conservation involved in the "creation" of two charges, as a charge is energy—potential energy with respect to every other charged particle in the universe. The "creation" and "annihilation" of charges also violates, as we have seen, causality.

We can further see *reasons* for some of the properties of

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the electron, properties totally inexplicable by conventional theory, properties that are just brushed aside with remarks like "Quantum mechanics is odd!" (Treiman, 2000)

This is only the beginning of the riches to be mined from taking these equations seriously. For as is well known, every unmeasured quantum entity evolves as a wave, yet every measurement reveals it to be a particle—as accurately as we can measure, a point-particle. (The latest measurements show the electron to be *smaller than* 10^{-18} m [Lederman, 1993], which is 2000 times smaller than the proton. And these measurements are consistent with a true point-electron.) However, there are severe difficulties with the point-electron model. A true point-electron, for instance, would have infinite density and infinite gravitational and Coulomb self-energy. Current theory is wildly divergent on this issue. The followers of Feynman and QED insist that everything behaves as particles, and QED treats them as point-particles (Feynman, 1985). Quantum field theorists insist that everything is wave or field, that particles are mere epiphenomena (Weinberg, 1977).

There is, however, a logical way of resolving these views. In order to negotiate the "two slit" experiment and its variants, the quantum object must have total knowledge of "the entire measurement situation"—in theory, the entire physical universe. That a single electron or photon should have such omniscience is of course absurd. However, if the unmeasured quantum object exists as a non-local, multidimensional, phase-entangled analog wave or set of interference patterns, as the equations and experiments insist, then any interaction or measurement would represent a digital slice of this analog wave. Our "quantum of time" τ would then represent the "reporting cycle" of this process, the minimum time between "reports." As Gribben (1998a) says, the universe seems to "make the computation and present us with the result." Thus, when a measurement or interaction happens, the analog wave is converted to a digital solution with the result reported to a specific set of coordinates—thus a "mathematical point."

Thus, every measurement or interaction involves an analog-to-digital conversion—and this involves a minimum quantizing error proportionate to the "quantum of time." This is the minimum time between digital "slices" of the analog wave, and so fixes the minimum "uncertainty" of the conjugate variables. This is the first *explanation* ever given for the uncertainty principle—it represents merely the minimum quantizing error. We can now see that the fundamental relation is that of time and energy,

$$\tau \bullet \Delta E \geq \hbar.$$

The other conjugate (complementary) properties derive from this.

Of course, the *units* of Planck's constant are the products of energy and time, the units of angular momentum, as in the above inequality. It has always simply been *assumed* that *energy* is the quantized entity, and you will find this stated as fact in textbooks. But a photon can have any energy (witness the results of a Doppler shift) and the equations of QM would work exactly the same if it is assumed that *time*, not energy, is the quantized entity.

It is perhaps unfortunate that QM came to maturity at the same time as Relativity. Einstein convinced everyone that a bastard unit, space-time, was a more accurate designation than either space or time separately. Thus physicists came to accept another bastard unit, the energy-time of Planck's constant, which is not even a true constant, but a *constant of proportionality*. Heisenberg (1938a, 1938b, 1944) always considered Planck's constant to be *shadow* or *projection* of some true constant in some other dimension, a constant that would explain the "size" of the uncertainty principle. The constant he arrived at was τc, $2e^2/3mc^2$, or 1.87×10^{-15} m. He attempted to cut the universe into tiny cubes τc^3 in size. This, of course, was a failure. However, one wonders why he never suggested the more natural unit τ as his "pure" constant. Could it be that he realized that if *time* were quantized, his "window" through which the paradigm had escaped would be nonexistent?

If we take Dirac's equation seriously, moreover, time *must* be quantized. As everyone from von Neuman (1928) to Pais (1993) recognizes, the equation describes a spinor field in which electron changes to positron and vice versa every 360°, which as we have seen is the time τ. If this change happened at random times, no charge could ever be measured, as our measuring devices don't work that fast. The result would be zero average charge. So every electron in the universe must change polarity *at the exact same instant*. In this case, at every phase angle opposite charges still attract, and like charges repel, no matter whether the lepton is nominally electron or positron at that instant. And since, as we will show, all matter is compounded of electrons and positrons, this means that all matter must change polarity in this same rhythm, the "quantum of time," which is the "clock speed" of "least count" of the universe.

In any case, Heisenberg clearly agreed with the above assessment of the "size" of the uncertainty principle. Moreover, our understanding that this "size" is the inescapable uncertainty involved in an analog-to-digital conversion clears up several further problems with the electron, particularly with the infinities involved in the "point-electron" model.

The Quantum Field

Assuming the reality of this negative energy epo sea, we can account for many of the hitherto mysterious properties of the electron. But how can we account mathematically for the sea itself? Here quantum field theory comes to the rescue. In his book *The Odd Quantum*, Sam Treiman (2000) introduces "only for pedagogical purposes" a very simple "model field": a single, scalar field $\phi\,(x,y,z,t)$ which classically obeys the linear differential equation

$$\frac{1}{c^2}\frac{\partial^2\phi}{\partial t^2} - \left\{\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2}\right\} + \rho^2\phi = 0.$$

Treiman then goes on to quantize the field, and solve for the eigenvalues. The results, as he states, are "quite remark-

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able." Notably:

> . . .The allowed momentum eigenvalues p form a continuum, all magnitudes and directions being allowed. For any given momentum p there is a particular state with energy
>
> $$E = [(cp)^2 + (mc^2)^2]^{1/2}, \text{ where } m = \hbar p/c.$$
>
> This is just exactly the relativistic energy-momentum relation that holds for a material particle of mass m. It is natural to interpret this state as in fact describing just that; we may speak of this as a one-particle state. A *particle* has somehow emerged out of the quantum *field*. The parameter p that we started with fixes its mass. [Emphasis his]

It is important to note that, to be accurate, the above expression should read "plus or *minus E*." The one-particle state can have either positive or *negative* energy. (Typically, as Dirac noted, the negative root is suppressed: if we pretend it isn't there, maybe it will go away.)

The remarkable thing is that, starting with a simple *field*, *particles* emerge as quanta of the field. Treiman further notes that there are families of one, two, or all possible numbers of particles. More, in multiparticle states all the particles must be *exactly identical*. And finally, this particular "model field," deliberately chosen for its simplicity, describes as its quanta *neutral, spin-zero bosons*. According to Treiman, ". . .it is easy to construct analogous linear theories for charged as well as neutral particles of various spins. Theories involving charge yield both particles and antiparticles as their quanta." (We have previously noted that the quantum spinor field governed by the Dirac equation has just such properties.)

We are looking for simplicity here, applying Ockham's Razor. And it turns out that the simplest possible quantum field would *necessarily* be populated with all possible numbers of *strictly identical, neutral, spin-zero bosons*. Such particles, as noted above, can have either positive or negative energy. To quote Gribbin (1998b), "In the quantum world a field *must* give rise to particles." (Emphasis his.) However, no such field of unlimited numbers of neutral, spin-zero *positive*-energy bosons exists. Why not, if a field *must* give rise to particles? However, as we have argued above, a "sea" of *negative*-energy, neutral, spin-zero bosons is a requirement of quantum mechanics itself: of the energy equation, and of the Dirac equation of the electron. Two of its solutions call for negative-energy electron-positron pairs, which would necessarily associate as neutral spin-zero bosons. Thus the *simplest possible form* that the Vacuum Electromagnetic Field could take would have as its unique solution exactly the same result as the Dirac spinor field: a "sea" of unlimited numbers of negative-energy electron-positron pairs. We have now approached this from three different directions, and they all point to the same result.

Treiman complains that, in the "model field" described above, there are no interactions. It is what is called a "free field theory," a theory free of interactions. Start with a state in which two particles approach as for a collision, and in fact they won't collide, because the classical field equation on which it is based is linear: the sum of any set of solutions is also a solution. (For this reason, quantum field theory, with its multiple fields, one for each "fundamental" particle, requires non-linear terms in the differential equations that describe them in order for there to be interactions, and this is why none of the theories are exactly soluble.) But as we noted above, this "free field theory" exactly describes our strictly identical, negative-energy boson sea, in which electron and positron approach as if for a collision, but in fact they don't collide, as they are both waves at the time. (We will later show that this lack of interactions between fields is a non-problem, because there *is* only one field, this simplest Dirac field.)

The form that this negative-energy boson sea must take can be seen as we *approach* the absolute zero state of the zero point. In laboratory ultra-cold studies, we remove "positive" energy and achieve lower temperatures to come closer and closer to "zero absolute," which is a state of *no positive energy*. That there is still immense energy ($h\nu/2$) at this zero point of *no positive energy* should immediately have informed us that positive energy is not the only kind of energy. So what is the alternative to positive energy?

As we *approach* the zero-point, some curious things happen. First, centered at about 2.73°K, we find an immense number of photons. Then, *at* 0°K, the equations of QM tell us that there is *unlimited* energy. Let's say you are approaching a wall. As you approach, you detect a large amount of energy. And *at* the wall, you find it is glowing white hot. You ask what is behind the wall, and someone tells you, "Oh, there is *nothing* behind the wall. The universe ends there." Would you be inclined to believe it? Yet that's what we are told about the zero-point. Energy and activity decline rapidly with temperature, then *near* the wall, suddenly there are immense numbers of photons, and *at* the wall, *unlimited* energy. But *nothing* is behind it. Believe that, and there are some bridges you might be interested in buying.

The matter that registers in our measuring devices is positive energy. But all matter except the electron is *composite*, and positive energy is pushing-apart or *explosive* energy. It takes immense *negative* energy to bind matter together. If positive energy were the only energy, one would think that at temperatures near absolute zero matter would lose its cohesion and fall apart. Nothing of the kind—in fact matter binds closer and closer together until it becomes all one thing. *It takes energy to bind matter together, yet all positive energy has been removed.* What is left? Only the *negative* energy that is the result of negative forces.

The Bose-Einstein Condensate

Various typical changes occur in the physical characteristics of material substances near 0°K. In a conductor, some of the electrons change their phase so that they become, in effect, positrons. An electron and this pseudo-positron then form what are called "Cooper pairs," bosons formed of two fermions, in which the two 1/2 spins add up to spin 1, and both must be in the same state governed by the same wave function. (The members of a Cooper pair are separated by about 10^{-6} m, thousands of times the distance between the ions in the conductor's lattice.) At even lower temperatures a true Bose-Einstein Condensate (BEC) may be formed, which acts as a single unit rather than as a collection of molecules. This permits the special states in which superconductivity and superfluidity occur. *These are very energetic states*, as their behavior demonstrates. They are states in which negative (binding) energy has overcome the tiny residual positive (freeing) energy, so that they are all governed by the same wave function.

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All this happens as we *approach* the zero-point. Order increases, everything is bound closer together. Negative (binding) energy becomes predominant. Everything seems to settle in toward a BEC. (Here we might note a further difficulty with the Standard Model and its Grand Unified Theories [GUTs]. These assume that at higher and higher energies the forces and particles lose their identity and unify. However, the experimental evidence points exactly the other way. Higher positive energies allow entities more degrees of freedom to resonate in more and different modes, whereas at lower energies they approach the BEC, in which the binding (negative) energy is so strong that the parts lose every bit of identity and must all be in the same state. This is emphasized by the failure of the prediction made by every GUT that the proton must be unstable. So far, no proton has ever been observed to decay. Result: no GUTs.)

A BEC can only result from the total dominance of negative (binding) energy over positive. Looked at that way, the interface between negative and positive is not 0°K, but a few degrees higher, perhaps around 2.7°K. In any case it is different for different substances, and certain BEC characteristics manifest themselves at much higher temperatures.

And *at* the zero-point, instead of *no* energy, there is suddenly a flood of it. (Zero-Point [ZP] energy—$h\nu/2$ for each mode of the vacuum electromagnetic field.) Why would this be, if there is "nothing" beyond it? *What generates this energy*, where does it come from, if it isn't another "miracle"? [Big Bang theory insists that the microwave background comes from the exact other end of the energy spectrum, from a state of infinitely high energy and temperature, created out of nothing: by a "miracle." We suggest that this is a violation of causality: infinite temperatures can not be a "proximate cause" of an energy field near 0°K. We suggest that the source of this energy should be sought nearer at hand, at the adjacent "zero-point" with its unlimited energy, and beyond, in negative territory. We will later look at this in more detail.] Again, this is *real* energy, with many measurable effects.

What becomes clear from all this is that the negative energy sea of bosons (epos) called for by the equations must exist in the form of a BEC. *According to the equations and everything we know, our reality is surrounded by and immersed in a vast, all pervasive Bose-Einstein Condensate.*

This is a rather startling conclusion. However, it is supported not only by the equations of quantum mechanics, but by a large and growing body of clear experimental evidence.

Bell's Inequality and the now numerous proofs thereof (Clauser and Shimony, 1978, Aspect *et al.*, 1982) demonstrate that our reality must be *non-local*, connected *faster than light*. As Nick Herbert (1985) puts it, "A universe that displays *local phenomena* built upon a *non-local reality* is the only sort of world consistent with known facts and Bell's proof." (Emphasis his.) Phase-entangled quantum objects share information apparently *instantaneously*, no matter how great their spatial separation.

Non-local or faster than light action also must be a property of the electromagnetic field, according to a whole series of experimental results starting with the Sherwin-Rawcliffe experiment (1960) and continuing with those of the Graneaus (1982, 1983, 1985, 1987, 1993) and Pappas (1983, 1990A, 1990B). These experiments all show that changes in the electromagnetic field must propagate much faster than light, apparently instantaneously, so that a moving charge has no "left-behind potential hill." Thus, changes in electromagnetic potential must propagate apparently instantaneously over any distance.

The same is true of gravitation, as was shown in the classical Laplace demonstration based on the absence of any change in the angular momentum of the earth's orbit (Laplace, 1966), and as has been repeatedly demonstrated by Van Flandern (1993, 1996, 1998). He shows that even in a static field, if gravitation propagated merely at light speed, it would result in a "couple," which would measurably increase the earth's angular momentum. This, of course, does not happen. He further shows that General Relativity, supposed to be a local theory, nonetheless assumes and requires instantaneous changes in the "curvature of empty space," and so is non-local.

Therefore, both electromagnetism and gravitation act *non-locally*. They also must be representative of the non-local reality that Bell's proof shows must contain the local effects we normally experience.

However, there is one and apparently only one extended structure that exhibits non-locality: the BEC. If you insert an electron into one end of a BEC, *however large*, an electron emerges from the other end faster than light can travel that distance—this is the phenomenon of superconductivity. This non-local action results from the fact that every constituent of a BEC must be governed by the same wave function and every part must be in the same state and therefore act as one.

Bell's proof and the experimental facts of electromagnetism and gravitation require a non-local reality. Dirac's equation, in requiring a universal BEC, provides just that. Therefore all these proofs of non-locality amount to proofs of a universal BEC, our one non-local extended structure. We will later demonstrate that these non-local actions are not literally instantaneous, but take the finite time τ. This results in clear, intuitive *non-local* models of electromagnetism and gravitation which nonetheless act by *direct contact*, and thus demonstrate *causality*.

We will show that this ends the centuries-long debate between those who accept the evident action-at-a-distance of gravitation and electromagnetism as unmediated and acausal and those who insist on causality despite the appearances. Accepting that we are imbedded in a universal BEC gives the best possible answer to both. As we will see, it provides *physical but non-local* models which nonetheless demonstrate direct contact causality.

From what we know of BECs from those we have managed to create in the laboratory, this BEC would be the daddy of them all. It is composed all of negative-energy, one-dimensional epos, all with identical negative energy (but no "mass"). Each epo is charge condensed so that each charge "sees" only its oppositely charged "pair" (as in the Cooper pair). No unbalanced charges allowed, no positive energy allowed, and the entire BEC described by a single wave function.

How many times must nature describe this to us, before we get the picture? We have looked at three equations, the energy equation, Dirac's equation, and this very simplest quantum field, which we might call the "Zeroth Quantum Field" (ZQF). Each of them seem to be describing this same object, a universal BEC composed of unlimited numbers of spin 0 neutral negative-energy bosons, which have to be one-dimensional electron-positron pairs.

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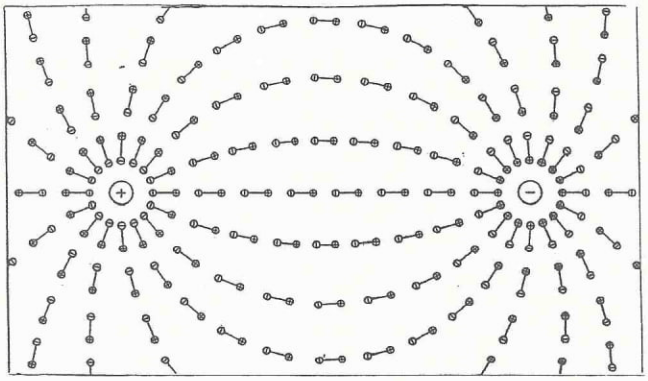

Figure 1. "Vacuum polarization" around unlike charges.

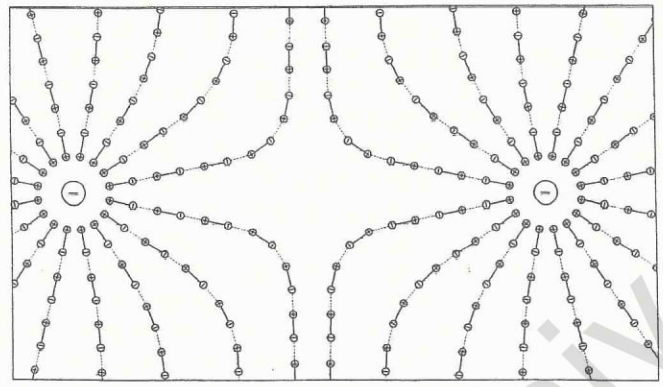

Figure 2. "Vacuum polarization" around like charges.

Of course, the BEC wasn't well described in 1934, so it is no mystery why Dirac didn't see that this is what his equation calls for. Only in the light of more recent findings is it evident that Dirac's "sea" must be a BEC. For, of course, it fills the crucial needs of Dirac's sea—it is "full," so that no positive energy particle can "fall in" unless it first loses all its positive energy, and then only if a balancing antiparticle similarly divests itself. Further, it has no "mass," hence no inertia or gravitational interaction, so it is virtually undetectable. [Haisch and Rueda (1997) insist that negative "mass" is impossible, since "mass" is a result of the action of the ZPF on polarizable entities. Since this would not include negative-energy epos in a BEC, they are quite correct. They don't have "mass." Negative *energy* is quite a different thing.] And as we will see, it is the source of the unlimited polarized electron-positron pairs that the Dirac equation requires, and experiment shows, to be surrounding every "bare" charge.

Physics Through the Looking-glass

Let's step back a moment and look at what the full Dirac equation and the simplest quantum field, the ZQF, seem to call for. As Gribbin (1998a) remarks, "In the quantum world a field *must* give rise to particles." Unlimited numbers of them, the quanta of the field. This is the famous "second quantization." According to QFT, there is nothing in the universe but quantized fields. We here invoke the *simplest possible* quantum field which *"must"* supply the unlimited numbers of epos called for by the full Dirac equation. The question might then be "Why would this ZQF supply *negative energy* epos? One would think that the first 'category' to be filled would have *positive* energy." Here we might recall that we call positive energy "positive" only because of Ben Franklin's mistaken choice. It would be much more logical to call the electron, the very unit of electricity, positive in sign, in which case what we call "negative energy" would be *positive energy*, and would *be* the first "category."

That there is a negative-energy "sea" balancing the positive energy of our reality restores the symmetry between negative and positive energy called for by the energy equation and Dirac's equation. Moreover, there are indications that negative energy is *primary*. This has profound implications.

For one thing, we can now follow the process miscalled "creation," and see where the energies come from. If the negative energy BEC is a completely filled sea of epos, under every mode of the vacuum electromagnetic field would be either an electron or a positron, one end of an epo—hence "half a boson." In terms of energy, "half a boson" is $h\nu/2$. This is exactly the zero-point energy called for by the equations. The electron and positron in the BEC have no positive energy, only charge. But together they make a neutral spin-zero boson whose energy is $h\nu$. In this case $\nu = 1/\tau$, around 1.6×10^{23} Hz. This would give the epo an energy ($E = h\nu$) of around 660 MeV, and give each "mode" of the vacuum electromagnetic field an energy of half that, 330 MeV. Thus the "Zero-Point Energy" (ZPE) and the jitter-motion (*Zitterbewegung*) caused by it both emerge as direct consequences of Dirac's equation. As we will see later, "half an epo" is also "half a photon."

The Electromagnetic Field

We have seen above that Dirac, Oppenheimer, and Heisenberg all proved that every ion must immediately be surrounded by unlimited numbers of the opposite charged ends of epos. Experiment has since confirmed this to better than ten significant figures. However, if these are "real" epos "created" by the charge, this makes the mass of the ion "slightly infinite."

There is a further problem with the conventional view. Unlimited numbers of epos means that in every direction from an electron, for instance, there would be the positron end of an epo. This would completely neutralize the charge of the electron, so that it could not be felt or measured outside of this surrounding sphere of positrons. Recognizing this, conventional theory supposes that the "bare" charge of the electron must be some unknown higher value, probably infinite, which the sphere of positrons reduces to the "dressed" charge that we measure (Pais, 1994). But this supposition ignores one little matter: if the "bare" charge of the electron were infinite, so would be the charges of the positron ends of the epos. Whatever "bare" charge one chooses to assign to the electron, it would be completely neutralized by this sphere of epos. Moreover, if the "bare" charge of the electron were infinite, the "bare" charge of the proton would also have to be infinite.

We have shown above that electron and positron must set up a stable relationship at a distance of τc, 1.87×10^{-15} m. However, this is the measured diameter of the proton, and in a nucleus the nucleons are packed closer together than this. Therefore, there is no way that the two protons in an alpha particle, for instance, could be shielded from each other, so if the proton had an infinite charge the alpha particle would instantly explode. What is true of the alpha particle is *a fortiori* true of nuclei with even more protons packed closely together. From this one must conclude that the proton can

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only have a charge of exactly +e. However, a proton *ion*, as shown by experiment, must instantly be surrounded by a sphere of unlimited numbers of the electron ends of epos. Since its charge *must* be exactly +e, this charge would be completely neutralized, which we know is not the case. So something is terribly wrong with the "conventional" view.

However, all of these difficulties disappear when regarded from the new viewpoint of an infinite sea of negative energy epos. An ionic electron must instantly be surrounded by a sphere of the positron ends of polarized epos, as has been verified by experiment. The positrons must form a sphere of diameter τc. But this takes *no energy*, since in the infinite sea there is already a positron and an electron at the exact points necessary to make that sphere of polarized epos, each radial to the ion. The only difference is that these are now *positive energy* epos, as their vectors point in *real* directions. So far this is the same as the conventional view, except that it does not violate conservation.

The story is not over, though, as each positron in the inner sphere has a potential induced by the ionic electron. (At that tiny distance, the force between electron and positron is enormous.) This would unbalance the epo, inducing a potential between the positron and its electron, which would again force the electron end to polarize another epo, and so on indefinitely, forming chains of polarized epos. These chains would continue into space until they terminated at a charge of opposite polarity. (See Figures 1 and 2.) Again, this in a way is the same as the conventional view: the equations call for unlimited numbers of epos. They do not, however, say *where they are*, and the conventional view does not carry the process to its logical conclusion, which is shown in Figures 1 and 2.

The equations call for a negative-energy BEC that fills all space, but nearly undetectably, since it vibrates in "imaginary" directions. It is full of equal numbers of positive and negative charges, but they are "charge condensed," so that each charge only "sees" its paired antiparticle charge, making a one-dimensional vibrating object similar to the "strings" in many of the popular string and superstring theories. This one dimensional string-epo can vibrate in any "imaginary" direction, but it must average τc in distance from its antiparticle.

However, a BEC cannot tolerate an unbalanced charge. Therefore, an unbalanced charge, an ionized electron for instance, must immediately be neutralized. As we have seen above, the equations call for it to be instantly surrounded by the positive ends of an unlimited number of polarized epos.

We can now see that this "neutralization of a bare charge" called for by the equations is a *requirement* of the BEC, which can't tolerate an unbalanced charge; however, it has unlimited (infinite) numbers of epos that it can throw at it, to neutralize it.

Therefore, each "bare" electron is immediately surrounded by unlimited numbers of epos. However, once again this would not solve the BEC's problem. *Only when every unbalanced charge is neutralized by chains of epos connecting it to and neutralizing every opposite unbalanced charge is the BEC again stable.* So the very stability of the BEC requires chains of epos in the patterns shown in these two figures. (And of course Dirac's equation calls for unlimited numbers of polarized epos—as is verified by experiment—but it doesn't state *where they are*. So this pattern is a direct solution to the equation.) Note that this result is only possible if the total number of positive and negative charges in the universe, whether in the "positive energy" realm or the "negative energy" realm or both, is *exactly equal*. And this means that the numbers in each can only change in pairs—epos.

Furthermore, however many epos the BEC "sacrifices" to accomplish this neutralization, the number of epos in the BEC remains *exactly the same*. Infinity minus infinity is still infinity.

According to the Zeroth Quantum Field and the "unexpurgated" Dirac equation, verified by experiment, this pattern *must happen*. Moreover, since this complete sphere of positrons would neutralize any charge of the "bare" electron, *this induction pattern is the only way any charge on the electron could be felt or measured outside this sphere*. Charge is carried *by proxy* by these chains of epos. The strength of the charge measured anywhere would vary as the inverse square of the distance, as the Coulomb gauge requires. (This strength would be measured in "epo chains per unit area," just as Faraday would have us measure "lines of force per unit area.") Since this pattern *must happen*, and since it duplicates every aspect of the electromagnetic field, as is easily verified, we submit that this *is* the electromagnetic field, much as Faraday or Maxwell would have drawn it, with Faraday's "lines of force" exactly duplicated by chains of epos.

The model exactly combines the properties Maxwell expected his mechanical ether to exhibit, embodied in his equations. This ether must, he argued, be in a condition of mechanical stress:

> The nature of this stress is, as Faraday pointed out, a tension along the lines of force combined with an equal pressure in all directions at right angles to these lines. . .From the hypothesis that electric action is not a direct action between bodies at a distance, but is exerted by means of the medium between the bodies, we have deduced that this medium must be in a state of stress. (Maxwell, 1873)

In this "epo model," the "tension along the lines of force" is supplied by the attraction between the aligned unlike charges in the epo chains. The pressure in all directions at right angles to the epo chains is supplied by repulsion between the like charges in different chains lined up roughly parallel to each other. This also accounts for the repulsion between like charges of "real" ions, as seen in Figure 2. (These features are recognized in plasma physics, where they are called "MHD" or "Alfven" waves. No satisfactory explanation has hitherto been given for them. It is, moreover, an effect that can not possibly be explained by the photon model.) And as Rosser (1971) showed, the magnetic force can be derived from the Coulomb force for charged particles in relative motion. A charged particle, negotiating this "field," would follow a curved trajectory exactly in accordance with Maxwell's equations.

Note that, in SED, the *quantized* electromagnetic field is successfully modeled as a collection of one-dimensional oscillators, each a vector whose direction and force are determined by its place in the "field." Our "epo model" of a vector field of one-dimensional (massless) oscillators is an exact analog of this model, "already quantized." The same is true of conventional quantum theory. As Taylor (2001) remarks:

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> In quantum theory, the electromagnetic field behaves exactly as an assembly of arbitrarily many massless particles. The number of particles of a given momentum and energy just corresponds to the energy level of the corresponding electromagnetic oscillator.

Further, we note that what had been taken to be a mathematical abstraction, the "electromagnetic field," now has a definite physical reality.

So, merely by considering what Dirac's negative energy "sea" *must* represent, we are presented with an unexpected bonus: the first *direct contact, causal, workable* model of an *already quantized* electromagnetic field.

Conservation of Angular Momentum (a.k.a. "The Photon")

If the epo is the quantum of the electromagnetic field, as shown above, this would seem to leave the "photon" in limbo. Let's look at a single electron of hydrogen, orbiting the proton at some energy level above its ground state. After a few thousandths of a second, it will jump to its ground state. To do so, it must lose *angular momentum*—spin—in the amount of $h\nu$. In the conventional view, the electron "emits"—instantly creates—a "particle" called the "photon," which is an electromagnetic "wavicle" traveling at velocity c and which delivers the angular momentum intact to some other electron, whereupon it is no more. Since Einstein banished the aether, however, the question has been "what is waving?" The photon has no rest mass, and contains no charges—so it violates our kinetic definition of energy.

However, in every situation in the macrocosm (and according to Newton's laws) in order for a "real" object to get rid of spin angular momentum, that real object must set some other real object spinning. Can the photon be the only exception? As we will see, it isn't. For while an electron in its ground state is "charge condensed," in that it only "sees" its proton, and its proton only "sees" it, an electron in a higher orbit has a slight unbalanced charge which must cause the BEC to surround it with epos, as above. And if an electron needs to lose spin, what more natural than that it set spinning those objects closest to it, the polarized epos that surround it? They have charges, and are pointing in "real" directions, so they can absorb the "real" (positive) spin energy that the electron has to get rid of.

So the electron gives a tiny sidewise "push" to certain positrons in the sphere surrounding it, and then it is "gone"—it is in its ground state. The epos are left "holding the spin," some more than others, because the lost spin is a vector quantity, and its energy will go primarily to epos that are pointing in the vector direction. Since the electron is gone, the epos are no longer in chains, and the spin energy will travel up the epo "string" (at velocity c) exactly the way a sidewise impulse will travel up a plucked guitar string. (Note that a sidewise impulse given to a charged particle [an "electric wave"] will, by Maxwell's equations, generate a magnetic wave at right angles.)

By the time the energy has reached the electron end, the electron has become a positron, again with a sidewise impulse, so to conserve angular momentum it must select and polarize some electron in exactly the right direction at the right distance. It thus initiates a vector line of epos, each carrying the spin energy "bucket-brigade" style at velocity c. Therefore the "photon" at this point would be a wave, carried by epos, spreading at velocity c in every direction, but with most of the energy carried by lines of epos pointing in the vector direction.

An epo carrying "real" angular momentum would change from a spin-0 boson to a spin-1 intermediate vector boson—vector because any amount of energy less than $2m_ec^2$ is unstable, and can only be carried for one-half cycle. Since it is unstable, it must dump the energy, polarizing the next epo in line. And since it is an "epo carrying a photon," we suggest the name "epho."

At this point the "photon" amounts to a wavefront traveling at c, a coherent bunch of intermediate vector bosons, each carrying a portion of the angular momentum. They take all possible paths, following the Feynman "path integral" or "sum-over-histories" version of QM, with most of the paths being cancelled by destructive interference. The remaining paths, summed, make up the amplitude, the Ψ wave. (Again, a "mathematical abstraction" takes on a certain physical form.)

Note how exactly the Feynman sum-over-histories method mirrors the actual process. Like Feynman's version, the "ephos" take all possible paths. Feynman breaks down each path into a series of short arrows or vectors, the directions of which, summed, keep track of the path's phase. We have seen that each epho *is* a vector, rather shorter than Feynman's, each epho being only 1.87×10^{-15} m long. Feynman could not explain why a "path" should have phase, he merely asserted that it did. We can now see that it has phase because each epho on each "path" is itself an electromagnetic wave with phase. Together they form a coherent wavefront. Ephos on the "least action" path will reinforce each other, and any epho that takes a "wild" path gets out of phase with the wavefront, suffers destructive interference, its angular momentum is cancelled, and it drops back into the epo "sea." Thus the only ephos that continue to carry energy are those that are close to the (least action) "classical" trajectory.

In the famous "two slit" experiment, many of the paths comprising the epho "wave" which represents the "single photon" go through each slit, and interfere with each other, forming the well-known Ψ wave "interference pattern." At the screen, one of them is randomly selected from this *densité de présence* according to $|\Psi|^2$, the probability, to deliver all of the wave's angular momentum to a single electron in the screen.

Again, the "collapse of the wave function" into a single result has never been given a satisfactory explanation. However, it seems likely that the first epho positron to select a "real" electron as its "other end" causes the collapse. Those who favor the "many universes" version of QM might say that *all* of the vector bosons deliver the full amount of angular momentum to different electrons, but in different universes. It is a good thing that angular momentum is conserved in this manner, one electron's discarded spin all being delivered to

> One of the tragedies of science is Lorentz's death in 1928, just as Dirac's equation was formulated, as Lorentz surely would have recognized the negative-energy sea as responsible for his electromagnetic aether.

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H. A. Lorentz (1853-1928)

another single electron, as otherwise we would never see the stars. (The wavefront of a single "photon" from a distant star can be bigger than a continent—if this energy was not delivered to a single electron, the energy would be so diffuse that we probably would never have become aware that stars other than our own sun existed.)

Considering the properties of the BEC, however, we can make a certain amount of sense of the process. The "rules of the game" seem to be that if the "photon" is generated by the jump of a single electron, the BEC must find a single electron, somewhere, to accept that angular momentum. (We may assume that the spreading Ψ wave carries as information a certain "memory" of how it was generated.) This amounts to an analog-to-digital conversion, with the sum of the angular momentum of the entire wave being delivered to a single electron, a "point event." As Gribbin noted, above, the universe "makes the computation" and presents us with the result. If, however, the signal was generated by the movement of many electrons as in a plasma or conductor, the resulting radio wave's angular momentum can set multiple electrons moving, as in an antenna.

So, again, another unexpected bonus: a model of the "photon" that doesn't violate the kinetic theory of energy. Note that the model gives physical meaning both to Feynman's path integral version of QM and to the Ψ wave.

Further, it should be noted that since each epho wave individually travels at *c*, the velocity of light would be independent of the velocity of the source, and the same in any frame of reference. It would in fact be Lorentz's electromagnetic aether (Lorentz, 1909). The transmission of light would agree with Lorentzian relativity, which meets all the tests devised for Special Relativity (Ives, 1946, 1949, 1950, 1951), including those that SR fails, such as the Sagnac effect (Sagnac, 1913) and the Silvertooth effect (Silvertooth, 1987, 1989, Silvertooth and Whitney, 1992). One of the tragedies of science is Lorentz's death in 1928, just as Dirac's equation was formulated, as Lorentz surely would have recognized the negative-energy sea as responsible for his electromagnetic aether.

In Part 2 (IE #44), the specific implications of the negative energy sea will be examined, which include everything from altered nuclear physics to the spacing of the planets.

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The Black Box Game:

Some Broader Aspects of Alternative Energy

Jon Norris*

Before one can break out of the box of conventional thinking, one must know where the boundaries of that box are. One of the tools that I use to observe how I look at the energy picture is a thing I call the Black Box Game.

The rules of the game are simple: an inventor creates a device, the Black Box, that can provide electrical energy by itself, is inexpensive enough for virtually everyone to afford at least one, and is easily available. What happens next is to begin to list and explore all the changes in society that would ensue from such a device becoming reality. The ultimate level of the game is to assume that the device can be made as small as, say a hearing aid battery (or smaller, if you wish), and that the amount of energy it can output is unlimited.

How would such a device change things? Usually, the first things to come to mind are those closest to our daily lives, such as heating and lighting our homes without wires or utility payments; electric cars, planes, ships, and other vehicles. How about self-powered appliances? Heated, well-lit highways for our electric vehicles; heaters to prevent frost damage to crops; unlimited fresh water and self-powered pumps to pump it to drought areas? Unlimited energy would mean the ability to drastically reduce the toxic byproducts of society and to clean up polluted land and water. The technological portion of the game can get quite interesting, and can be instructive in observing how we use energy in our daily lives. It can also show how we are constrained by the limitations of our current (pun intended) system.

What begins to emerge after the initial rush of technological ideas is the secondary social and economic impact. Electric cars mean no more gas stations or petroleum fuel infrastructure. That means economic dislocation on a rather large scale. The same with natural gas, propane, and so on. Of course, there is the conversion of old and the manufacture of new vehicles, replacing power meters with Black Boxes, etc. There would be new industries and jobs based on the new technology, but there would still be widespread economic shifts, and loss of money and jobs in many sectors.

The effect on the stock and futures markets would be dramatic, to say the least. There would be more than one person calling for the destruction of the devices. There would be a massive push to make them illegal. The military and intelligence community would want them to be secret weapons and kept from general use. They would see the economic impact as a threat to national security and would try to confiscate the patents and devices.

Of course, all this mess would be short term, and in the longer term negative reaction to the technology would be seen to be the paranoia that it is. All of the above problems could be solved by proper planning and programs designed to make the transition as easy as possible. Other very pervasive industries have been changed before. How many icemen or ferriers do you know? The negative effects would be far outweighed by the lives saved and improved by the Black Box.

One aspect that I have found particularly interesting is the hidden energy cost in things. If we can generate all our own electricity for free, then the energy portion of manufacturing items drops to nearly zero. For energy-intensive products like metals, the cost reduction could be significant. Transportation costs also have large energy components, and would see significant drops. As the cost of raw materials and component parts drops, so does the cost of finished items. These hidden costs compound in complex products, and there would be a ripple effect as energy costs plummet. Not only do you save on lighting and heating the store where you buy the item, you save on the transportation energy costs, the manufacture of the transport vehicle's component parts and their shipping, and on the manufacturing and component manufacturing for the item you buy as well as its packaging. It can get complicated.

There are negative sides to the Black Box. Unlimited energy could make some enticing weapons (as well as defenses). Unlimited energy would tempt designers to be sloppy in the efficiency of their designs, as with the software bloat that accompanies increasingly large hard drives in computers.

A decentralized, free energy society would better serve humankind than a controlled, smoothly operating ant farm.

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Unlimited energy would mean that people might get careless about wasting heat and energy, and that could have negative environmental consequences.

One can go on like this for some time, but it pays to stop at some point and begin to analyze what one is seeing. Just what am I learning here?

First, by looking at what we could do with the Black Box but cannot do now, much is revealed about the extent and limitations of our energy infrastructure and policies. It becomes clear very quickly that being so deeply involved in a petroleum fuel-based mindset causes serious problems for the future. The size and ubiquity of the petroleum infrastructure makes any major change an excruciating proposition. Our cities, our vehicles, our highways, tax structure, and so on are all designed with petroleum fueled vehicles as a central fixture. We are constrained to "grandfather" this 100-year-old technology into all of our plans, which complicates the transition. This is not to mention the political clout of the economic elite from the oil crowd, which is extremely significant. The same is true of the nuclear industry and the electrical utility industry. These groups and their stockholders have a significant interest in preserving their status quo, and will fight innovation that deprives them of earnings and power, regardless of the long term effects on humanity as a whole.

The economic gains from large centralized structures like the power grid are now being offset by the economic effects of brownouts and blackouts. Micropower generation, a lovely new buzz phrase, is heralded as the next thing in energy. This exciting new business innovation is only about thirty years behind the curve in alternative energy circles. Nice to see some people catching on to the situation, but a lot more people need to get a lot more up to speed if we are to avoid a devastating crisis. Granted, improvements in small generating technology have helped with this, but the innovations that have made this change viable could have been done a long time ago. This leads to the question of research dollars, subsidy policies, and so on.

One of the things learned from general systems theory is that "loose" systems function better. The "tighter" a system is, meaning the less tolerant of anomalies, the more likely it is to fail, and the more likely that failure is to be catastrophic. The electric grid has shown itself to have an increasingly unacceptable level of intolerance to real world fluctuations. Smaller clusters of decentralized systems, even down to the building level, perform better in many respects than the current grid structure. They also have the advantage of easier upgrades to new technologies. At least one major bank has realized this and moved off the grid and onto fuel cells. This is a trend that will only grow.

This does, however, give us a hint as to the key to making transitions to new technology—money. Yes, when all appeals to reason, ethics, the environment, and posterity fail, good old cash flow will usually (not always) drive the decision. Since we exist in a capitalist system, this is to be expected, and can be used to advantage.

This leads to one more interesting observation. One of the main things that jumps out at me from playing this game is that there are essentially two worldviews at odds here. One worldview concentrates on short term profit and stability for the status quo, while the other worldview sacrifices short term fluctuations in stability and profit for longer term gains for society and humanity as a whole. This is where we get down to what the "alternative" in alternative energy is really all about. It is not so much about technology as it is about a view of the purpose and meaning of society. How one views society's purpose determines how one sees the technology being used.

If one believes that the purpose of society is to create a sort of human ant farm, with bustling little worker/consumer drones all milling about in orchestrated chaos, then the petroleum-fueled, electric grid economy works just fine. Stability and smoothness of function are the important target parameters, and the occasional wiping out of the colony by major catastrophes is simply to be expected. The colony can be rebuilt with new worker/consumer drones and started again. No problem. Since nothing beyond the ant farm concept is expected or desired, replacing one set of worker/consumer drones with a new set fits the plan nicely.

If, on the other hand, one views society in light of its service to the individual, one comes to a different understanding of things. If one values the contributions of individuals, and therefore individuality itself, then society's job becomes the nurturing and protection of the individual so that the individual can make his/her contribution. This view of society is the one that produces culture, art, music, and all the things that one generally thinks of as the measure of a society. If you haven't guessed by now where I stand on this divide, it is on this side.

I look at it very simply: individuals can survive without society, but society cannot survive without individuals. Therefore, the existence of the individual is primary, and that of society secondary. Society exists to serve the individual, not the other way around. A decentralized, free energy society would better serve humankind than a controlled, smoothly operating ant farm. It would be quirky, confusing at times, boisterous, noisy, and more than a little obnoxious, but it is the only society worth inhabiting.

This is the society that the Black Box could enable, and it is the direction in which most alternative energy points, to one degree or another. A world where all people have access to adequate energy, housing, food, clothing, and decent work at fair wages is very much in keeping with the environmental and socio-political goals of alternative energy. Decentralizing the energy infrastructure would make it more efficient, more responsive to new technology, more user-friendly, less expensive, more robust, and capable of serving the best of human goals.

These are the lessons I take away from playing the Black Box game. Now, while the actual introduction of the ultimate Black Box is still more in the realm of science fiction, there are indications that we are closer than most people might think. Even without cold fusion and the other radically new types of energy right around the corner, we are in a position to start taking the lessons learned from intellectual exercises like this game and put them to use.

The final purpose of the game is to imagine the most perfect or ideal situation and work backwards to see how close

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we can get to the realization of that dream. Even with only the "regular" alternative energy sources now available, it has been recently estimated that we could be generating 20% of all domestic energy needs in the U.S. in less than twenty years, saving nearly half a trillion dollars in the process.

Even greater progress could be realized with more emphasis on increased efficiency in our energy use. (We waste over 90% of the energy we use, according to some estimates.) Imagine how much we would gain if one-tenth of the hot fusion budget was spent on improving LEDs for lighting use, and subsidizing replacement of incandescent bulbs with compact fluorescent ones?

I know first hand the difficulty of trying to get people to move to more energy efficient designs. I have been interested in the Monolithic Dome Institute's design for concrete domes for many years, and have tried in vain to get local government and the small university I work for to consider this construction technique in designing new buildings. On large buildings, this technology can save over 30% on construction costs, and HVAC energy cost savings of up to 75% have been documented. The buildings are fireproof, earthquake proof, tornado proof, insect proof, and can have R-ratings of 60 or more. They can be constructed quickly in almost any weather, and have a tremendous capacity for design variation. Sounds like a wonderful technology, doesn't it? The trouble is, domes are round. People don't "get" round when it comes to buildings. No amount of discussion about the huge savings and design possibilities could get people past the buildings being round. So, we end up paying millions more for substantially less value in a building than we could get with readily available technology. Huge savings and safety factors are tossed out in favor of some arbitrary idea of aesthetics. No wonder we have an energy crisis.

Education is necessary, but it may take a massive crisis for some people to get past their prejudices. I would hope that through forums like this magazine we can get enough people thinking ahead to avert such a crisis, but that may take a more large-scale change in human consciousness. Nevertheless, we must keep trying to educate and enlighten. It would be really nice if those in the environmental movement would take the time to learn about cold fusion and other new energy technology, and put their considerable political weight behind more intelligent energy research policies. We must also push for more open inquiry into different models in energy science, such as those being worked on by Tom Bearden, Myron Evans, and Paulo and Alexandra Correa. This is where the Black Box might be hiding, and these areas are the real "alternatives" in alternative energy.

About the Author

Jon Norris is a twenty-seven year veteran of the telecommunications industry. He began his study of anomalous data and fringe science in the late 1960s after exposure to John Campbell's editorials in *Analog*. He is currently the team leader of a teleproduction facility at a small university. Mr. Norris continues to comb the fringes of science for valuable information.

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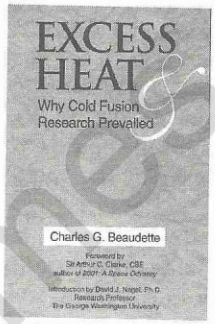

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Enhancement of Cold Fusion Processes in Palladium by Catalytic Agents

R.H. Parmenter*

The process of fusion of a pair of deuterons into an α particle in palladium metal can be enhanced by the presence of free protons. The process of fusion of lithium 6 and a deuteron into a pair of α particles can be enhanced by the presence of free neutrons. In both cases the enhancement is appreciable.

Consider the following reactions in palladium metal:

$$^{1}H^{1} + {}^{1}H^{2} \rightarrow {}^{2}He^{3} + 5.40 \text{ MeV} \qquad (1)$$
$$^{2}He^{3} + {}^{1}H^{2} \rightarrow {}^{2}He^{4} + {}^{1}H^{1} + 18.26 \text{ MeV.}$$

A deuteron and a proton in a tetrahedral cavity in the metal fuse to form helium 3 and 5.40 MeV. The energetic helium 3 crashes into another deuteron in a neighboring cavity, forming an α particle, a proton, and 18.26 MeV. The net result is identical to the direct fusion of a pair of deuterons into an α particle.

$$2\ {}^{1}H^{2} \rightarrow \alpha + 23.66 \text{ MeV.} \qquad (2)$$

In (1) the proton serves as a catalytic agent and is not consumed. In the first reaction of (1) and in that of (2), the factor limiting the process is the Coulomb repulsion partially screened by the conduction electrons of the metal. In the second reaction of (1), the energetic helium 3 easily overcomes the Coulomb barrier. The rate λ at which a reaction can occur is proportional to the Gamow penetration factor exp[-2πη], which is the probability of quantum mechanical tunneling through the Coulomb barrier. Some years ago, Parmenter and Lamb[1] calculated the rate at which a pair of deuterons in a tetrahedral cavity in palladium would fuse to form either a proton and hydrogen 3 or a neutron and helium 3. In their last paper they found

$$\lambda = 9.1757 \times 10^{-24} \text{ sec}^{-1} \qquad (3)$$
$$2\pi\eta = 81.0184.$$

This same value of 2πη is appropriate for the reaction of (2). For the first reaction of (1) however, 2πη will be smaller. This is because η is proportional to the square root of the reduced mass of the reacting particles. Thus the η of the first reaction of (1) will be smaller than that of (2) by a factor of $(2/3)^{1/2}$. The Gamow penetration factor for the first reaction of (1) will be *greater* than that of (2) by the factor

$$\exp\{-81.0814\ [(2/3)^{1/2} - 1]\} = 2.90 \times 10^{6}. \qquad (4)$$

This suggests that the rate of fusion of a pair of deuterons into an α particle will be strongly enhanced by the presence of free protons. The energetic α particles of reaction (1) can generate energetic deuterons in the metal by elastic collisions, which in turn can lead to enhancement of the processes considered by Parmenter and Lamb.[1]

This work was inspired by the remarkable results of Mizuno *et al.*[2] These workers used two electrolytic cells, the first one with a reagent containing heavy water, the second one with a reagent containing light water. A palladium cathode was placed in the first cell and electrolysis was performed for three hours, thereby loading the cathode with deuterons. Following this, the cathode was inserted into the second cell and electrolysis was started. After a sharp increase of the voltage on the cell was initiated, a large burst of neutrons was observed. A possible explanation is that the voltage jump caused a large concentration of protons immediately below the surface of the cathode amongst the deuterons, thereby initiating the catalytic process described earlier. The fact that the burst of neutrons did not last may be due to the large concentration of protons near the surface decreasing because of diffusion into the bulk of the cathode.

One type of reagent used in electrolytic cells may be formed by inserting lithium metal into heavy water, generating LiOD. This allows both deuterons and lithium 6 to be present in the cell. Consider the following reactions:

$$^{3}Li^{6} + n \rightarrow {}^{1}H^{3} + {}^{2}He^{4} + 4.78 \text{ MeV,} \qquad (5)$$
$$^{1}H^{2} + {}^{1}H^{3} \rightarrow n + {}^{2}He^{4} + 17.50 \text{ MeV.}$$

A lithium 6 nucleus and a neutron react to form a triton (hydrogen 3), an α particle, and 4.78 MeV. The energetic triton crashes into a deuteron, forming a neutron, another α particle, and 17.50 MeV. The net result is identical to the direct interaction of a deuteron and a lithium 6 nucleus to produce two α particles.

$$^{3}Li^{6} + {}^{1}H^{2} \rightarrow 2\ {}^{2}He^{4} + 22.26 \text{ MeV.} \qquad (6)$$

In (5) the neutron serves as a catalytic agent and is not consumed. In the first reaction of (5), there is no Coulomb repulsion to inhibit the neutron from interacting with the lithium 6 nucleus. In the second reaction of (5), the energetic triton easily overcomes the Coulomb barrier. In the reaction of (6) however, the factor limiting the process is the Coulomb repulsion partially screened by the conduction electrons of the metal. This suggests that the rate of interaction between a deuteron and a lithium 6 nucleus to form a pair of α particles will be strongly enhanced by the presence of free neutrons.

In an experiment studying this catalytic reaction, the electrolytic cell should contain sufficient volume of reagent in order that free neutrons can thermalize inside the cell. An external source of neutrons may be necessary in order to maintain the density of thermal neutrons inside the cell sufficiently high for the catalytic process to proceed. For the same reason, the cell should be surrounded by a shield reflective for neutrons.

In conclusion, cold fusion processes in palladium can be enhanced by catalytic agents.

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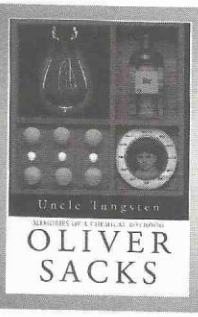

Uncle Tungsten: Memories of a Chemical Boyhood

by Oliver Sacks
ISBN 0-330-39027-9
$25.00 Hardcover, 337 pp.
Picador Press, 2001

Review by Soo Seddon

I have always had a healthy respect for obsessives. Therein lies genius or madness or, more often, both in equal proportion. Oliver Sacks' boyhood obsession with chemistry, however, was what kept him dangerously sane.

Predestined by his parents to be a doctor, he was, from age eleven, relentlessly pushed towards fulfilling their ambitions.

His gynecologist mother saved him the most medically intriguing aborted fetuses and stood over him while he painstakingly dissected them. She even arranged for private anatomy lessons and completely failed to notice that carving up the earthly remains of a child his own age might perturb him somewhat. He fretted that his overexposure to disease and death might render him incapable of any real affiliation with the "warm, quick bodies of the living."

Little wonder he sought sanctuary in less harrowing scientific pursuits.

The Sacks family were a pretty eclectic crowd. His maternal grandfather, an inventor, had corresponded extensively with the Wright Brothers, who made a special trip to meet him when they visited London.

One uncle was a highly regarded physicist and his Uncle Dave (the Uncle Tungsten of the title) was a chemist, whose factory made lightbulbs using filaments of the metal he so revered.

Sacks would spend all of his available time at the factory laboratory where, under the watchful guidance of his wolfram-fixated uncle, he would explore the properties of every chemical he found there.

Eventually he set up his own lab at the family home in London, which soon became fully equipped with many exotic and often toxic substances. His parents tolerantly had a fume cupboard installed for him when a misguided experiment filled the house with cloying hydrogen sulphide fumes.

All things chemical fascinated him to the exclusion of everything else. His description of seeing, for the first time, the Periodic Table in the London Science Museum verges on the erotic. It was, said Sacks, the most beautiful thing he had ever seen.

His love affair with the elements expanded into every realm. He even collected bus tickets with numbers corresponding to Mendeleev's table and didn't stop until he had the full set.

Every event in his life was held up to impartial, and rigorous, scientific study. Severe visual disturbances as a result of migraine attacks were regarded by him as an interesting study in natural stereoscopy.

It is not clear whether his only childhood pet, an octopus who lived in his bathtub, was kept for purposes of companionship or biological curiosity.

A large part of the book (which is a little too liberally dusted with footnotes) extols the virtues of Sacks' experimental heroes and, as such, is an informative and entertainingly written guide to some of the world's greatest scientists.

Tantalizingly, however, there is not a lot of Oliver Sacks the individual in the book. He endured the mandatory English public school bullying, an experience from which his brother, Michael, never recovered. Teachers agreed that the earnest young Sacks suffered from a bad case of "too muchness" and one school report declared that he would go far if he didn't go too far.

After a time he received only vague attentions from his distracted parents who, when they tired of his endless questions, happily referred him onwards to pick the brains of other, more finely-focused relatives.

It was the ordered predictability of chemistry he chose to surround himself with. The unsurprising and safe, the known and the measurable. Which is why the newly emerging theories of quantum mechanics distressed him beyond belief. It was too much of an unnervingly abstract concept for a hands-on experimenter to embrace.

Sacks, it appears, ultimately shrugged off his boyhood obsession with relative ease soon afterwards. The onset of puberty, he believed, created in him a more powerful effect than any which had resulted from his past chemical combinations.

The Golem: What Everyone Should Know About Science

Harry Collins and Trevor Pinch
ISBN 0-521-35601-6
Cambridge University Press, 1993
Out of Print, Newly-Titled Edition Available

Review by Thomas E. Phipps, Jr.

As far as I know, bird watching has not yet been recognized as a subject worthy of academic credit. Scientist watching, however, seems to be shaping up nicely in that regard. Harry Collins, one of the authors of this book, is a Professor of Sociology and Director of the Science Studies Centre at the University of Bath; the other author, Trevor Pinch, is also academically employed in the Department of Science and Technology Studies at Cornell. Despite these backgrounds, their book is not burdened with jargon nor loaded with footnotes. In fact, this is one of those rare instances in which some readers might wish for footnotes to facilitate further inquiry. For the authors have chosen their topics well and each of the seven chapters, addressed to a different case in the history of science, tells a compelling tale, well-narrated so that anyone can follow. The birds are reported just as they were seen under high magnification, with nits as in life and feathers in realistic disarray.

Among the cases considered are Eddington's pivotal proof of relativity theory by eclipse observations in 1918, whereby he momentarily set aside his own theorizing to borrow an experimentalist's hat, through which he proceeded to enunciate claims of arc-second resolution on a cloudy day using a 4-inch telescope strapped to the back of a running camel with hiccups (no, I trifle with the truth. . .the camel was drunk, to be sure, but the allegation of hiccups was never proven); cold fusion, with the stampede to judgment already familiar to readers of this journal; a controversy involving Louis Pasteur concerning the generation of life; Joe Weber's work at the University of Maryland, in which he observed gravity waves that nobody else could detect; a controversy among voyeurs of "the sex life of the whiptale lizard"; and

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one mildly representative case of Big Science in action, the problem of the missing solar neutrinos.

How does the Golem come in? As a metaphor for the metastable good-bad aspects of modern science. This is an ambivalence that goes back at least to Faust. Frankenstein's monster was patterned on the original Golem, which was supposed to have been created by a sixteenth century cabalist in Prague. As metaphors go, the monster seems to me a bit heavy-handed, rather as if one were to use science to frighten fractious children into good behavior.

I found the case histories more impressive than the conclusions on "putting the Golem to work." But throughout the book the authors have thought objectively on their subject and offer a number of acute observations. For instance, on the "unmaking" of science. (This is like the unlearning of one's education, perhaps the supreme intellectual challenge faced by any of us in life—one that few are successful in meeting.) Or on the "experimenter's regress," which arises from the dilemma faced by an observer who fails to confirm unexpected results reported by a previous investigator. Did the second observer fail because nothing was there or because of personal experimental incompetence? The regress arises wherever there is genuine ignorance about nature's ways. ("We don't know if we have built a good detector until we have tried it and obtained the correct outcome, but we don't know what the correct outcome is until. . .") It becomes particularly poignant when complemented by a "theorist's paradox," which is converse to the other, in that it arises through a putative absence of ignorance; *e.g.*, through propagation of a myth that science is "almost finished"—meaning that ignorance (open-mindedness) is no longer scientifically respectable. (Suppose a good theory is defined as one that answers all questions, and suppose we have a good theory, but we don't know if any theory is good until we have tested it against unanswered questions, which don't exist if we have a good theory. . .)

I think you will find this small but pithy book, as I did, well worth reading. It cannot fail to induce in the public mind a soberer and more realistic appraisal of that *science* which has become an increasingly central element in modern life. One looks forward with mixed feelings to the day when all children are reared as scientists and all humanity lives in squalor because nobody does the plumbing. (This, like so much else, was anticipated in the description of Laputa by Jonathan Swift—an author you would be even better advised to read, but unexpurgated, not in the version for children.) Myself when young did eagerly frequent the halls of science and, like many before and after me, came out by the same door where in I went. But the experience, coupled to subsequent observations, provided me with certain rules of thumb that may be appropriate to pass along to ever-burgeoning generations of the age that is waiting before, with the intent of greasing their destined downward path. The following Six Laws of Scientific Success are therefore offered as my own version of "what everyone [who plans to participate] should know about science."

1. Rid your mind of false conceptions created by popular fairy tales, such as that scientific contributions are judged on their merit.

2. Exalt not thy life form; recognize it for what it is: the lowest. . . to wit, the salesman (or, to be politically correct, the salesperson). See *Death of a Salesman*.

3. Be aware that every salesman has two items to sell, a product and a metaproduct. The metaproduct is himself. See *Death of a Salesman*.

4. Recognize that sales of those two items are strictly non-commutative. Sell first the metaproduct, then the product. Order your life accordingly. It is essential that the metaproduct be sold *before* extensive effort is wasted in design or manufacture of the product. (How do you suppose the infant Julian Schwinger got his Harvard professorship and his pink Cadillac? Was it by producing and selling a Nobel Prize-winning product? No, no, a thousand times no; it was by selling the metaproduct. The product came in due course, as nature intended.)

5. Unavoidably, it is necessary to produce some sort of product (however shoddy) to sell. Do not imagine, just because this is the easy part, that it can be neglected altogether. . .pure metaproduct never suffices. The drill is this: If you have already sold the metaproduct then its purchasers will unanimously work their heads to the bone for both you and your product, *because they fear appearing to be foolish purchasers*. Your subsequent success thus becomes essential to them. Whereas if you have not sold the metaproduct then they will slam the door on you and your product *because they fear appearing to be foolish purchasers*. Your subsequent failure thus becomes essential to them.

6. Observe that the merit of your product enters nowhere. The laws of success (and failure) are, as we say in mathematical physics, invariant under merit transformations—a fact that reflects a fundamental symmetry of nature embodied in a Principle of Relativity of Merit. This in turn harmonizes with the Principle of Least Action, which specifies that your earthly judges (editors, referees, scientific authorities) find it less action-demanding of them to consult their prejudices, fears, precedents, commitments, etc., than to consult your product.

In connection with the fifth point, let me tell a fairy story of my own. Once upon a time on a dark and stormy night there enrolled at Harhar University a pre-adolescent mathematician named J. Archibald Greensprout. He was much younger than anyone else in his class. He was scruffy, arrogant, antisocial, in apparent need of a bath—all the indelible marks of mathematical genius. His classroom activities seemed limited to mathematics, and very little of that, as he mostly cut classes. How he performed in the classes he did attend nobody inquired, as it was universally accepted that genius is not to be trimmed to fit classroom measures of merit. In short, J. Archibald succeeded beyond the dreams of avarice in his achievement of Phase I, the selling of the metaproduct. But alas, the ending is not that of a proper fairy tale. After J. Archibald left Harhar, not a word more was ever heard of him. He vanished into the maw of real life as if swallowed by a Golem. It seems that he overlooked Phase II, the production of a product. Had there been any product, anything at all, legions of Deans and Heads of Departments from the four corners of the academic Earth, seconded by swarms of *New York Times* reporters, would have shaken the firmament with acclamations. . .although had you or I, neglectful of the crucial Law 4, produced identically the same thing it would have been ignored.

Sociologists take note: From the foregoing simple rules it should not be difficult to construct a "model" of modern science. . .one that ought to be fairly successful, of its kind. That is, it should possess predictive value. It should predict what meaning attaches to "scientific progress," what kind of people succeed in the science game, and what kind of science coinage they mint. ❐❐❐

New Energy Times Archive

ECLECTIC OBSERVER

Compiled by Eugene Mallove

Response from the Vice President's Office

I was happy to receive this letter from the Office of the Vice President—a response to my December 14, 2001 letter to Vice President Dick Cheney:

Office of the Vice President
Washington

March 13, 2002

Dear Dr. Mallove:

I am writing on behalf of Vice President Dick Cheney to thank you for sending him your letter concerning the potential of cold fusion and the copy of *Infinite Energy* magazine. He has shared it with his policy staff.

The Vice President appreciates your taking the time to write and sends you his best wishes.

Sincerely,
Cecelia Bozer [hand-signed in original letter]
Special Assistant to the Vice President for Correspondence

For the first time in almost thirteen years of the cold fusion conflict we have a high-level statement, albeit *pro forma*, from the Executive Branch of government that a positive assessment of cold fusion has been "shared" with "policy staff." My letter that prompted the above response:

December 14, 2001

Dear Mr. Vice President:

I wish to bring to your attention a matter of great urgency on the path to a lasting victory over terrorism and to achieve enduring peace. A remarkable discovery made in the United States in the 1980s has been overlooked, because of a serious flaw in our funding for nuclear research. This matter is of the gravest concern, because it is a proven method to extract clean energy from simple, abundant materials. It has yet to be reduced to practical application, but with your help it could be. And—there are significant national security issues connected with it that are being overlooked due to bureaucratic inertia!

Please read the open letter that begins on the cover of the enclosed magazine, which is widely distributed in the United States and is received in 42 countries, I am happy to say. Our readers would very much appreciate learning of your response. In the past, we have received considerable support from U.S. Senator Robert Smith of New Hampshire on this issue, but he and we have been blocked by incompetent bureaucrats in the Department of Energy.

I wrote to you earlier this year on this very topic. Indeed, you will find my "Memorandum to the White House" posted on our website (www.infinite-energy.com). Perhaps amid the intensity of your demanding work, you were unable to respond earlier, or maybe your staff did not believe or recognize the significance of the message. The time has now come for you to render your judgment and assistance during this period of national tribulation.

I write to you again in a humble and hopeful spirit after the appalling terrorist atrocity against our beloved country and the world. It is a new day and I applaud your determination to destroy terrorism wherever it hides or rears its fanatical, ugly head. It appears that your effective action is working. I personally approve of using measured and crushing military power to administer infinite justice on the road to enduring freedom. But eliminating terrorism demands using every tool in our possession, as you have so rightly said. Please, Mr. Vice President, heed our call to investigate a remarkable, overlooked weapon for peace and lasting freedom from terrorism.

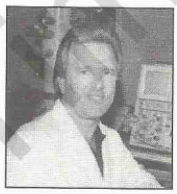
I humbly ask the favor of your reply.

All good wishes,
Dr. Eugene F. Mallove
Editor-in-Chief, *Infinite Energy* Magazine
Director, New Energy Research Laboratory

Paul Brown, Nuclear Waste Photo-Deactivation Creator, Dies in Car Accident

Press Release Received from Nuclear Solutions, Inc.

Nuclear Solutions, Inc. (OTCBB:NSOL) announces with regret the death of Dr. Paul M. Brown. Dr. Brown was killed on April 7, 2002 in an automobile accident in Boise, Idaho. He developed the idea for the company's patented photoremediation technology for the remediation of nuclear waste that will now be his legacy. He is survived by his wife and two children.



"Our team is saddened by this tragic loss, however, we remain fully committed to realizing the vision that Dr. Brown inspired us with. His vision holds the promise of safe and economical treatment of nuclear waste and the potential for a new generation of power reactors," said John Dempsey, Executive Vice President and Chief Operating Officer.

"We have assembled a management and scientific team that is competent and fully capable of implementing the technology that Dr. Brown invented as well as our newer acquisitions such as our GHR tritium removal technology," he concluded.

John Dempsey and Patrick Herda, co-founder and Vice President of Business Development will direct the company's activities until a new CEO is appointed by the company's board of directors. Their efforts will be supported by Dr. Qi Ao, Vice President of Research and Development and Adrian Joseph, PhD., Vice President of Special Projects.

The application of photonuclear physics to nuclear waste is called Photodeactivation. Photodeactivation involves the irradiation of specific radioactive isotopes to force the emission of a neutron, thereby producing an isotope of reduced atomic mass. These resultant isotopes can be characteristically either not radioactive or radioactive with a short half-life.

The fundamental mechanism works on the laboratory scale, and preliminary research suggests that this technology will also work on the industrial scale. NSOL is taking the steps necessary for commercialization of the technology. As for most of the advanced nuclear technologies developed today, computer simulation is one of the most important and necessary steps. NSOL will use and improve a series of nuclear simulation codes.

—End of Press Release—

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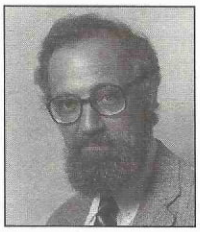
Infinite Energy covered the photodeactivation work of Dr. Brown in Issue #21 (August-September, 1998) with an article by him, "Neutralizing Nuclear Waste Using Applied Physics," and with another, "The Photon Reactor: Producing Power by Burning Nuclear Waste," *IE* #27, 1999. We also covered his earlier work with nuclear batteries, *IE* #13-14. Dr. Brown was a good friend whom we much enjoyed meeting at various new energy conferences. His energy and spirit will be sorely missed.

Hot Fusion's Harold Furth Dies

Harold Furth, 72, director of the Princeton Plasma Physics Laboratory from 1981 to 1990 and a researcher there since 1967, passed away February 21, 2002. Furth's pride and joy, the tritium-contaminated Tokamak Fusion Test Reactor (TFTR), was shut down at Princeton in 1997 and is still being disassembled. In 1999, Furth became professor emeritus of astrophysical sciences at Princeton University.



In 1989-90, Furth was one of the less vocal critics of cold fusion. He testified before Congress about cold fusion in April 1989, just before the floodgates of anti-cold fusion bigotry were opened by his associates at the MIT Plasma Physics Center. Furth would write frivolously in *Science* in 1990 (Vol. 256, pp. 1522-1526): "Electric plants of the same output ratings tend to have similar overall size and the prospect of building power stations out of billions of palladium cells instead of a few tokamaks, would not be a clear winner."

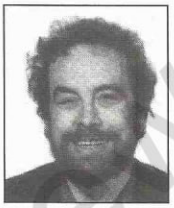
Born in Vienna, Furth immigrated to the U.S. in 1941. After studying at Harvard, he worked as a researcher at the Lawrence Radiation Laboratory in Livermore, California. Furth, an amateur poet as well as a plasma physicist, had some of his work published in the *New Yorker* magazine. In one poem, "Perils of Modern Living," published in 1956, he posited a meeting between Dr. Edward Teller and an alien twin:

> Well up above the tropostrata
> There is a region stark and stellar
> Where, on a streak of anti-matter
> Lived Dr. Edward Anti-Teller. . .

Lawrence Lidsky, Hot Fusion Critic and MIT Professor, Dies

The following obituary for Professor Lawrence Lidsky, authored by Robert J. Sales of the MIT News Office, is reprinted (in part) from the March 6, 2002 MIT *Tech Talk*:

Retired professor Lawrence M. Lidsky of nuclear engineering, who went public with his reservations about the efficacy of fusion as an energy source after devoting his career to its development, died Friday [March 1st] at his home in Newton after a 17-year battle with cancer. He was 66 years old.



Lidsky, a Cornell University graduate whose MIT doctoral thesis in 1962 was titled "Plasma Generation and Acceleration," was assistant director of the Plasma Fusion Center when he published an article in 1983 titled "The Trouble With Fusion" in *Technology Review*. He wrote the piece, Lidsky said at the time, because "I couldn't get an internal discussion going. Some didn't care and some didn't want to know." A short time after the article appeared, Lidsky resigned his position at the Plasma Fusion Center. Congress reduced funding for the fusion program by 5 percent the next year. It was renamed the Plasma Science and Fusion Center in December 1997.

"Larry Lidsky was one of the smartest people I ever met," said Professor Jeffrey R. Freidberg, head of the Department of Nuclear Engineering. "He was often way ahead of his time in delivering insightful and crucial analysis of the prospects of both fusion and fission power. In the fusion area, Professor Lidsky was one of the earliest engineers to point out some of the very, very difficult engineering challenges facing the program and how these challenges would affect the ultimate desirability of fusion energy. As one might imagine, his messages were not always warmly received initially, but they have nevertheless stood the test of time."

Lidsky later became a passionate advocate of the development of meltdown-proof Modular High Temperature Gas Cooled Reactors, which depend upon nuclear fission rather than fusion for their energy. Initially, the idea engendered little enthusiasm in the United States, but in recent years the idea resurfaced "in a much more friendly environment," said Freidberg. "Our department is leading a national research effort to construct a largescale test facility based on this concept," he said. "Many of the technical ideas are directly attributable to Larry's early analysis. "Such plants are now being developed in Japan and elsewhere."

Lidsky, born in New York on October 15, 1935, grew up in Brooklyn and attended Brooklyn Technical High School. He received a B.Eng. from Cornell with honors in 1958. . .

Upon graduation, Lidsky matriculated in the nuclear engineering graduate program at MIT while his wife attended Harvard Law School. After receiving the Ph.D. in 1962, he joined the faculty as an assistant professor. He became an associate professor in 1968 and full professor in 1976. He was appointed associate director of the Plasma Fusion Center in 1978.

He was the founder and first editor of the *Journal of Fusion Energy* and a major contributor to the departmental report, "Nuclear Power Plant Innovation for the 1990s: A Preliminary Assessment," published in 1984. . .

Lidsky served as a consultant to the U.S. General Accounting Office, the Office of Technical Assessment, the National Science Foundation, the Princeton Plasma Physics Laboratory, the Oak Ridge National Laboratory and the Argonne National Laboratory. He consulted on energy programs and policies in Japan, the Netherlands and Norway and lectured widely.

—End of the *Tech Talk Obituary*—

I was happy to have known Professor Lidksy as a friend and scientific colleague during my work at the MIT News Office (1987-1991). In *Infinite Energy* #24, March/April 1999, our 10th Anniversary of Cold Fusion issue, I wrote favorably about Lidsky's hot fusion opinions:

"In October 1983 MIT Professor of Nuclear Engineering, Lawrence M. Lidsky, published an article ('The Trouble with Fusion') condemning the hot fusion program. It was a high-profile cover story for MIT's *Technology Review*. The stark black and white cover of the issue read, *'Even if the fusion program produces a reactor, no one will want it.'* Other key remarks made by the outspoken Lidsky, who was then an Associate Director of the Plasma Fusion Center: 'Long touted as an inexhaustible energy source for the next century, fusion as it is now being developed will almost certainly be too expensive and unreliable for commercial use.'; 'The scientific goal of the fusion program turns out to be an engineering nightmare.'; 'A fusion reactor might well produce only one-tenth as much power as a fission reactor of the same size.'; 'The drawbacks of the existing fusion program will weaken the prospects for other fusion programs, no matter how wisely redirected.'

"Foreshadowing the benefit of cold fusion that would emerge over five years later, Lidsky also wrote of aneutronic hot fusion: 'Neutrons induce radioactivity and damage reactors. Neutron-free fusion might provide inexhaustible, benign power.' Prof. Lidsky later moved into work at MIT on advanced fission reactors, but kept an open mind about cold fusion after it emerged." ❐❐❐

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Coverage of the Ninth **International Conference** on **Cold Fusion** (ICCF9) *will appear in Issue 44.*

Windpower 2002
Portland, Oregon
June 2-5, 2002
Watch www.awea.org for information as it becomes available.

PLEASE NOTIFY *Infinite Energy* of any energy-related events scheduled in your area.

Energy 2002
Energy Efficiency Expo
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www.energy2002.ee.doe.gov

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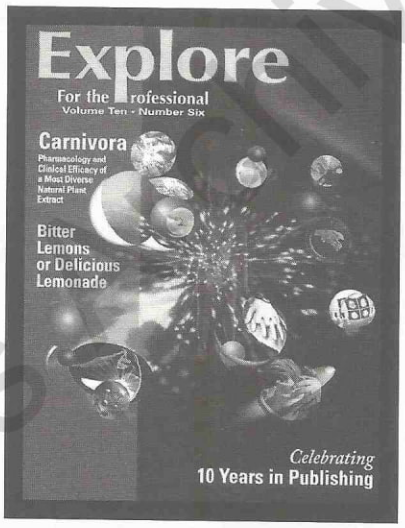

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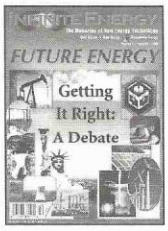

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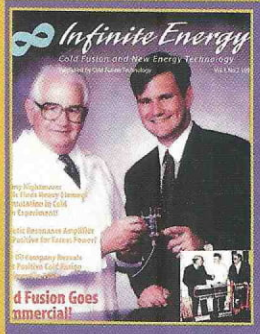

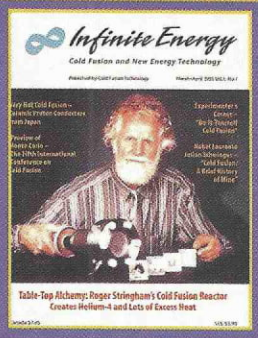

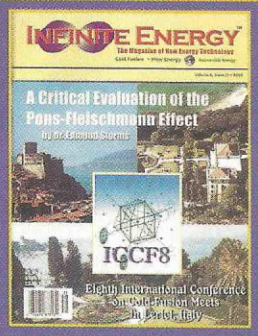

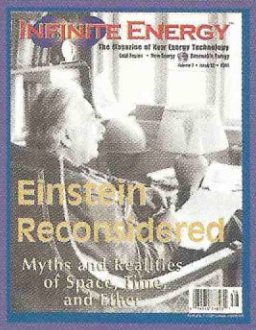

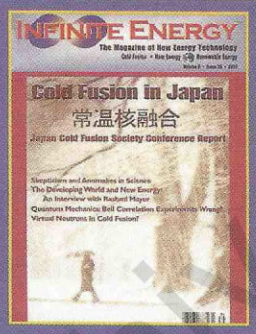

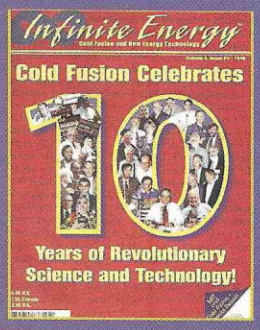

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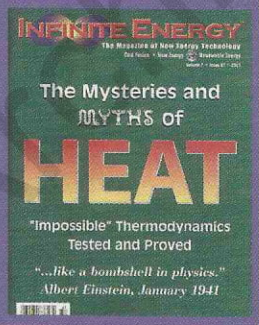

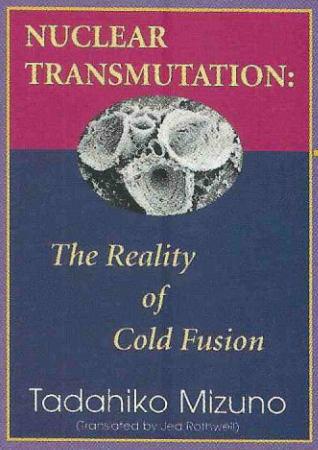

Nuclear Transmutation: The Reality of Cold Fusion

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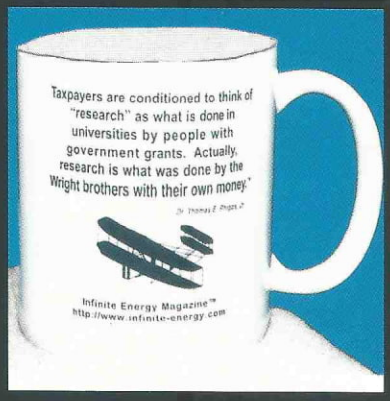

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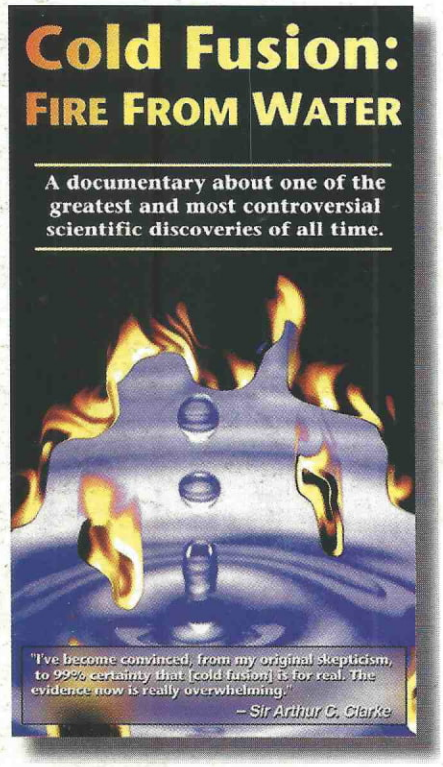

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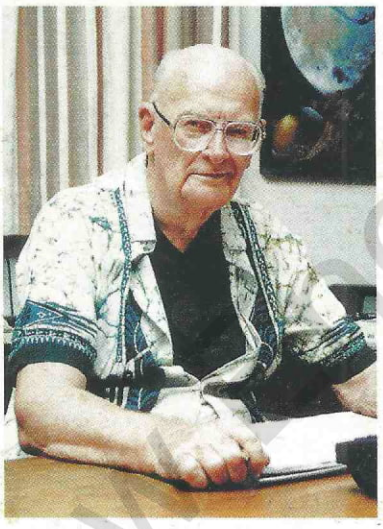

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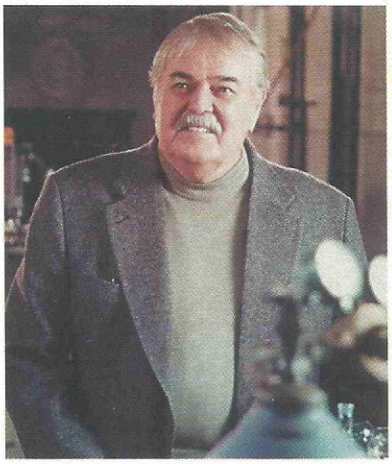

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